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COST-DRIVER ANALYSIS FOR COMPUTERIZED PRODUCTION PROCESS PLANNING--ETC(U)

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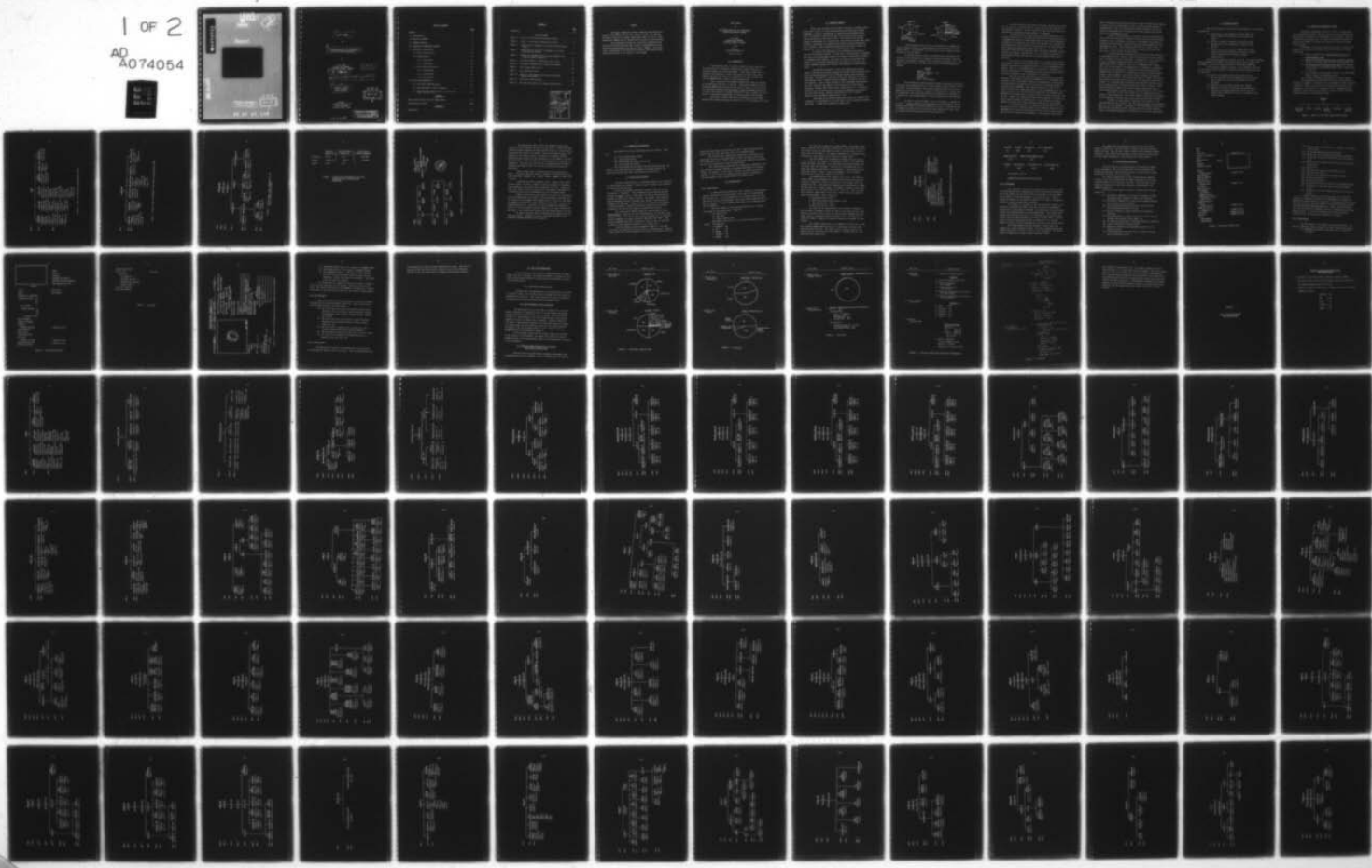
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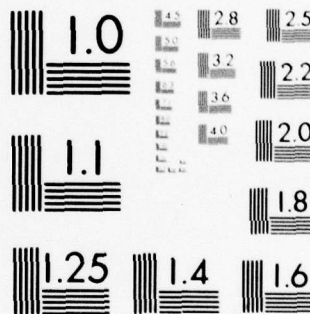
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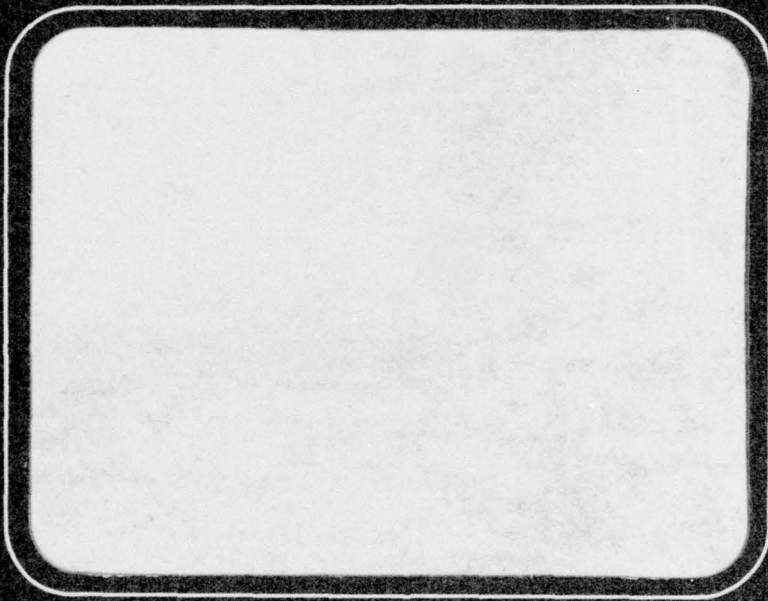
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FINAL REPORT

on

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COST-DRIVER ANALYSIS FOR COMPUTERIZED
PRODUCTION PROCESS PLANNING

to

U.S. ARMY
MISSILE R&D COMMAND
REDSTONE ARSENAL, ALABAMA

11 20 July 1979

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by

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PREFACE

This report summarizes research conducted under Contract No. DAAK40-77-R-0138 from June 30, 1977, to May 31, 1979. The work was performed by Battelle's Columbus Laboratories (BCL) for the U.S. Army Missile R&D Command with Mr. Richard Kotler serving as Project Monitor.

This program was carried out in Battelle's Engineering and Manufacturing Technology Department through the Design/Manufacturing Interaction Program Office, Mr. Bryan R. Noton, Manager. The authors wish to acknowledge the contributions of Battelle staff members Wendy Freeze and Don Roop in the conduct of this program.

FINAL REPORT
on
COST-DRIVER ANALYSIS FOR COMPUTERIZED
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U.S. ARMY
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REDSTONE ARSENAL, ALABAMA

from
BATTELLE
Columbus Laboratories

July 20, 1979

1.0 INTRODUCTION

The spiraling costs of military systems in recent years reflect the high levels of technological sophistication needed to meet the ever increasing demands for system performance. These high systems costs have produced a new awareness in recent years within the DOD of the need to identify the high cost areas in the manufacture of these systems, and initiate MANTECH (MT) programs to reduce systems costs.

With a multitude of MT program possibilities, comes the problem of deciding which can yield the best ROI. Quantitative methods for determining how MANTECH money should be spent does not exist. To this end, the U.S. Army Missile Research and Development Command (MIRADCOM) entered into a contract with Battelle's Columbus Laboratories (BCL) to examine the potential for a quantitative methodology for assessing further MT programs.

This report outlines the results of Battelle's efforts toward meeting these objectives during the period July 1, 1977 through May 31, 1979.

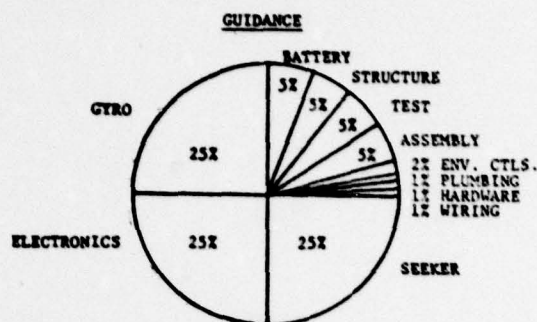
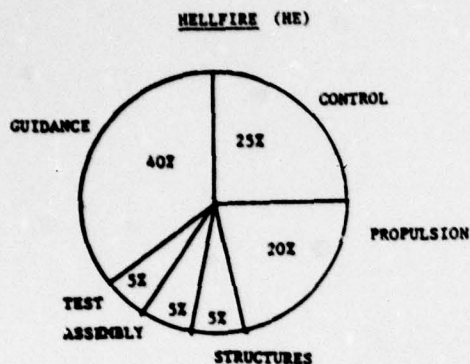
2.0 EXECUTIVE SUMMARY

Abstract → This report describes the work done by Battelle's Columbus Laboratories (BCL) for the U.S. Army Missile Research and Development Command (MIRADCOM) to develop a methodology for examining missile manufacturing costs, cost drivers in manufacture, and future missile MANTECH programs from the standpoint of best ROI of funds. This objective has been met through the development of a missile parts classification system (MPCS) which provides a methodology for examining cost drivers in missile manufacture plus a variety of other interactive possibilities achievable through the availability of cost information at the discrete part level.

As devised, this methodology will accommodate both present as well as future missile systems. In other words, the methodology is designed such that as new technologies develop, the system is sufficiently flexible to accommodate these changes. Data would be stored and retrieved from a computer to allow general comparisons of costs which will identify cost drivers, MANTECH projects with high ROI, and estimates of future missile costs. ← *Abstract*

The MPCS was developed in "tree" form drawing upon existing similar classification systems including MIL STD 881A "Work Breakdown Structure" and the proceedings of the 1975 Missile Manufacturing Technology Conference. The missile is initially divided into sections titled Structural System, Control, Guidance, Missile Assembly, Propulsion, and Test and Inspection. Each of these sections is then subdivided using descriptors that categorize the makeup of each section such as Wire Harness, Gyroscopes, Finishes, EMI Control, Seals, Flight Motor, etc. Further expansion of the tree evolves until six levels of breakdown yield discrete part data which reflect component characteristics such as material, physical size, performance characteristics, etc.

The system as now devised would use pie charts to indicate cost breakdowns and percentages at all levels down to and including the discrete part level. A sample cost breakdown is shown below.



This system would show costs as a percentage of an assembly cost which is some percentage of a larger assembly cost and finally the total missile itself. In this manner, the cost drivers will be evident as major divisions of the pie charts.

At the discrete part level, as indicated above, additional data could be stored relating cost to material, fabrication methods, production quantities, performance, component size, processing requirements, etc. The example below shows part data which could be used for missile design/cost analyses.

FAIRING

Length - 3 feet
 Production Quantity - 500
 Lot Size - 25
 Aluminum
 Formed Plate
 Cost - 2.35 man-hours

This information would be gathered through a reporting system which contractors and subcontractors for a specific missile system would be required to provide. The availability of this type information would allow the designer of new missile systems to ultimately access this data, conduct trade-off comparisons, and obtain some relative cost comparisons to determine if a specific part can be manufactured, by what processes, from what materials, etc.

In order to access the MPCS, it will be necessary to computerize the data. A coding system was developed which is an alpha-numeric code and separates each branch of the parts classification tree. It allows the user to address any particular data location so that comparisons of part costs can be made within the same missile or between missiles.

The data stored at each point in the parts classification system will be set up in a similar format to allow quick and easy comparisons of any portion of interest. The data required to make the system useful was studied and an appropriate display method is recommended.

The MPCS with its coding system, data display techniques, and proposed incorporation of cost data and discrete part characteristics, can, if implemented, meet the proposed objectives that this program addressed. In addition, the possibility also exists that the MPCS, as a standardized reporting system, could be used for costs as well as the standardizing of parts numbers and engineering drawing identification. For example, all "actuators" would have the same basic MPCS code number regardless of manufacturer, performance characteristics, etc. with further coding used to differentiate between actuators and the relative manufacturing costs of each type.

As a result of this program effort, it is evident that an MPCS, if available, could have far reaching impact on cost data acquisition and analysis and missile part identification for all future MIRADCOM missile systems. Thus, it is recommended that the evolution of the MPCS be continued by development of an implementation plan and more detailed study of cost data availability, form, and methods of acquisition.

Now that the basic methodology has been developed and the MPCS devised to serve several functions if implemented, it is recommended that a further study be undertaken to develop an implementation plan/road map that would define the approach and time table for installing the MPCS as a working tool at MIRADCOM. This would be basically carried out by a review of current cost reporting practices, both at MIRADCOM and at selected missile contractors, along with detailed discussions with MIRADCOM staff responsible for present cost reporting practices and others within the Army and DoD. Present cost reporting systems would be examined to evaluate the scope, features, method of operation, etc., and to define any thread of commonality between the current reporting system and the proposed MPCS.

It is anticipated that the implementation plan would reflect the fact that any new cost reporting system of this magnitude would have to be implemented over a critical time period and only on those missile systems which are now in research and development or the advanced concept stage.

These considerations would define how best to apply the MPCCS missile systems in various states of development in order to define the best approach to implementation. Thus, all non-production missile systems now at various stages of development would be examined and systems targeted which would best fit the implementation plan.

Based on this information, a prospectus would be developed which would outline the features of the MPCCS, its short term and long term impact on missile costs, an estimate on the return on investment which might be realized once the system is operational, and make some assessment of total implementation costs. This prospectus would also, of course, contain a time table and key marketing and technical development activities which must occur in order to meet this time table.

A second important consideration and one which relates closely to an implementation plan, involves a study of the whole area of data acquisition. The MPCCS as currently developed, if implemented in total, would constitute a tremendous undertaking in data acquisition and undoubtedly require many years to complete. Thus, it is recommended that an added effort as the first phase of implementation be to undertake to examine the whole area of data acquisition. Consultations would be held again with MIRADCOM staff involved with cost reporting, and selected missile manufacturers to obtain feedback on the various levels of detail that might be incorporated in the MPCCS. What effect these levels of detail would have on data acquisition and collection practices by the contractors would also be studied. It is proposed that the guidance and propulsion sections be used as the target areas for examining the question of data collection. These areas represent the highest cost areas in missile manufacture and are sufficiently different in nature to give a broad prospective to the program.

The output of this effort would be a full understanding of the question of data acquisition, how the data might be collected, the mechanics of data collection, and what type of data reporting form would be needed.

The MPCCS, as now developed, represents a new approach to part classification and cost analysis. The full potential impact of this development has yet to be assessed. Performance of the implementation plan development and cost acquisition efforts indicated above will provide important input to forthcoming assessment of the MPCCS and its potential applications.

3.0 PROGRAM APPROACH

The initial approach to developing the methodology in this program consisted of:

- (1) Establishing a work breakdown structure (WBS) for a missile system, its subsystems, and subsystem components
- (2) Collect and analyze government and missile system manufacturer's cost information for insertion into the WBS
- (3) Manipulation of cost data into formats which would display cost-driver information and provide a methodology for manufacturing technology program prioritization.

Five missile systems were selected for study. Two were air defense missiles (REDEYE and STINGER), two ground-to-ground combat missiles (TOW and DRAGON), and an air-to-ground missile in development (HELLFIRE).

As the program progressed, however, it was found that cost data in the form and detail necessary for meeting the above program plan were not available.

As a result, the program approach was altered in that

- (1) The data available from the HELLFIRE missile system was used to define and refine the methodology as it was developed.
- (2) Extensive cost acquisition efforts were stopped.
- (3) Emphasis was placed on developing a methodology which could meet the program objectives plus be used for missile parts classification and cost estimating of new missile systems.

4.0 OVERVIEW OF METHODOLOGY DESIGN

Methodology development evolved as a result of establishing a parts classification system. The other portions of the methodology were then developed according to the requirements of that system. The parts classification development will be reviewed in subsequent sections that review the development of coding, data acquisition, and data storage/display systems.

Development of the parts classification system is based on the combination of applicable information from several sources. The main sources were:

- (1) Military Standard 881A, Work Breakdown Structure for Defense Materiel Items
- (2) Report of the Missile Manufacturing Technology Conference held at Hilton Head, South Carolina, 22-26 September 1975
- (3) The Seventh Quarterly Design-to-Cost Report from Rockwell International on the HELLFIRE modular missile system dated 31 July 1978
- (4) Data collected from the project offices on the TOW, DRAGON, REDEYE, STINGER, and HELLFIRE missiles.
- (5) Catalogs, textbooks, and handbooks on various subjects.

The complete parts classification tree plus coding system is described in Appendix A. Evolution of its development is shown in Figures 1 through 6. Figure 1 shows the first level based on division of the missile into six sections. (A comparable tree for "command and launch equipment" could be developed and added to complete the major hardware-related portions of a total missile system.

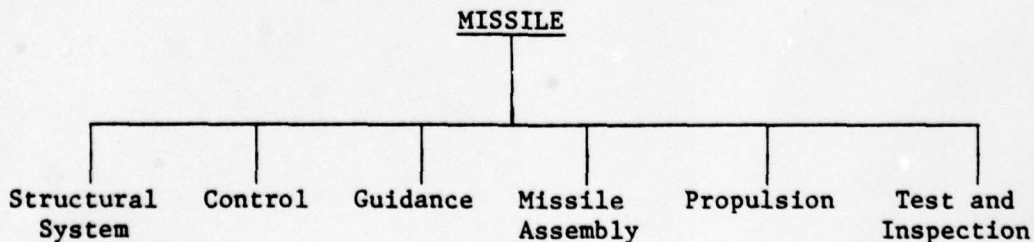


FIGURE 1. LEVEL 1 OF THE PARTS CLASSIFICATION SYSTEM

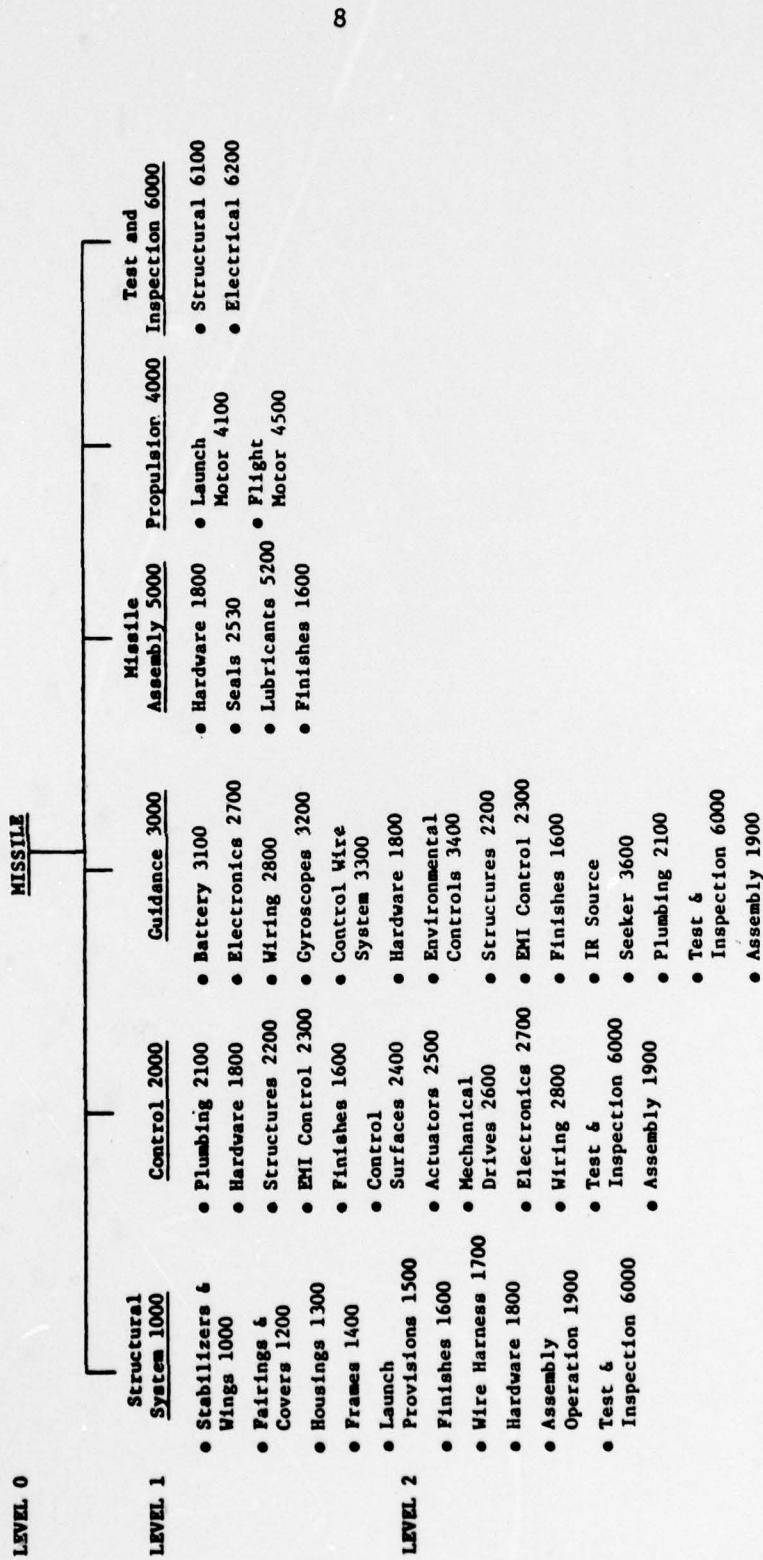


FIGURE 2. LEVEL 2 OF THE PARTS CLASSIFICATION SYSTEM

CONTROL 2000



FIGURE 3. TYPICAL LEVEL 3 BREAKDOWN OF THE PARTS CLASSIFICATION SYSTEM

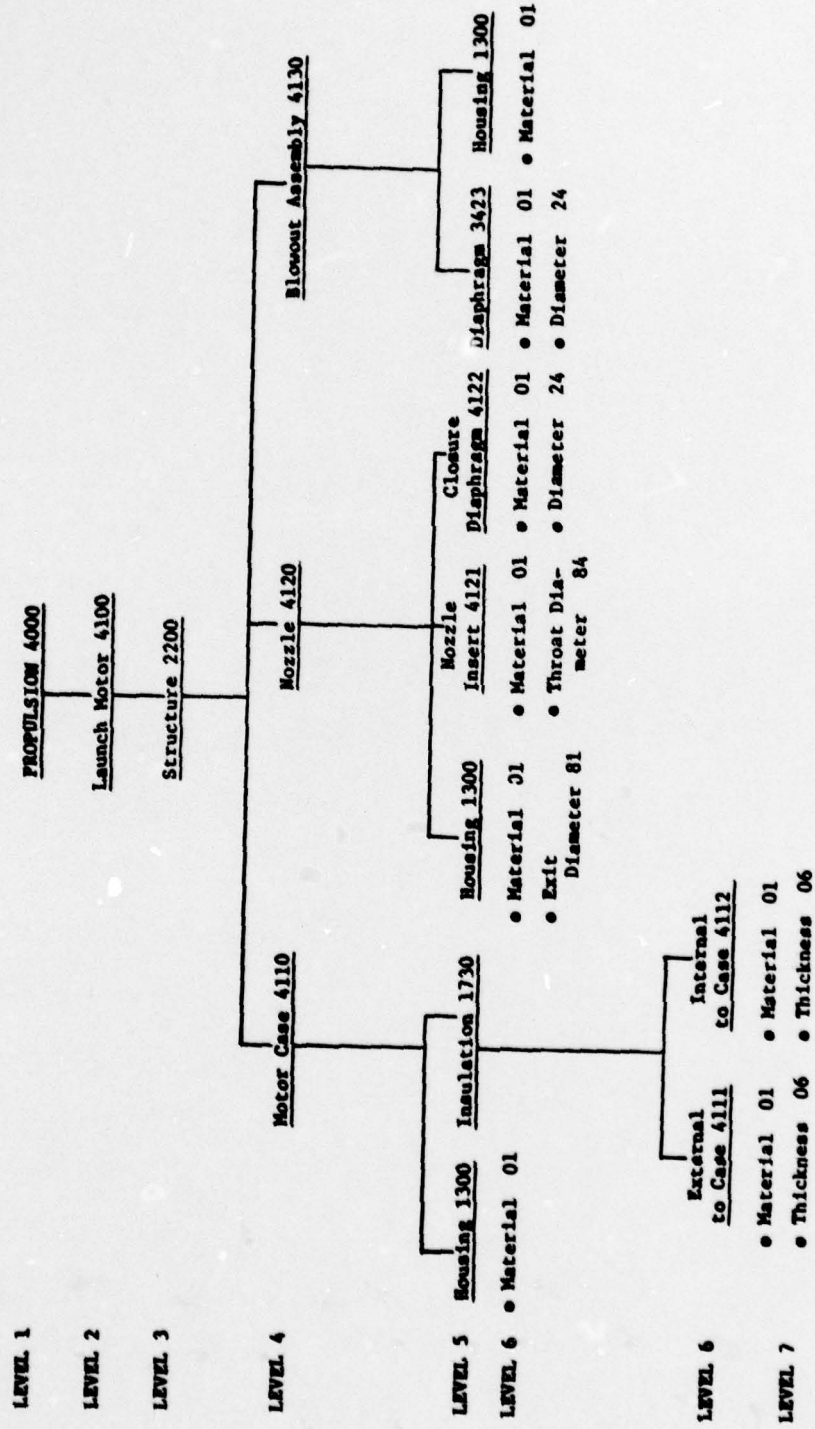


FIGURE 4. TYPICAL LEVEL 6 AND 7 BREAKDOWN OF THE PARTS CLASSIFICATION SYSTEM

	Collector Current 31	Collector-Emitter Voltage 32	Current-Gain Product Bandwidth
Transistor	<50 mA	<40 V	<100 MHZ
Bipolar	50-500 mA	40-80 V	>100 MHZ
Signal	>50 mA	>80 V	

FIGURE 5. TYPICAL PART CHARACTERISTICS AND COST CATEGORIES FOR A BIPOLAR SIGNAL TRANSISTOR

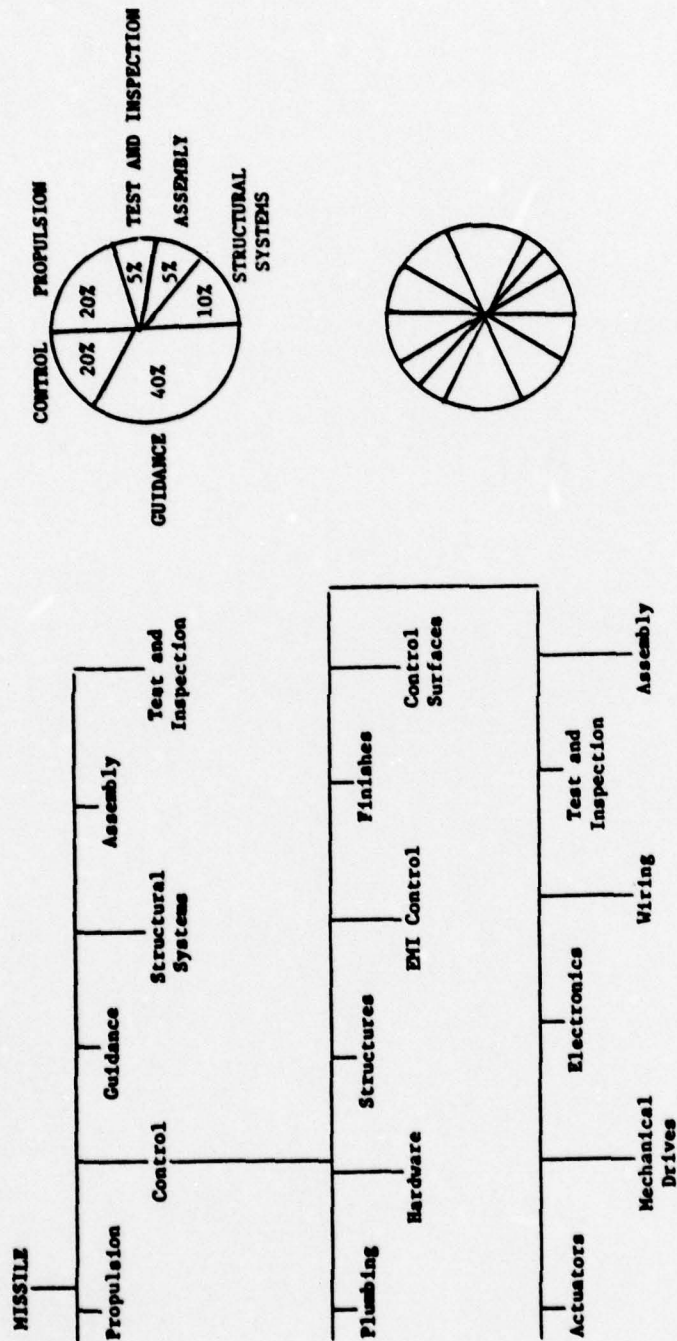


FIGURE 6. PIE CHART METHOD OF ILLUSTRATING COST DRIVERS

The descriptions used to define the component sections were selected to best illustrate the parts in that section. These terms sometimes have general meanings and some confusion arose as to where specific parts should be located. For example, does the gyroscope belong in the guidance or the control section? To address this problem, specific definitions were written for each descriptor as it was added to the parts classification. A list of terms with their definitions is contained in Appendix B. (The gyroscope is placed in the guidance section because it determines the missile direction but does not physically change that direction).

Figure 2 shows Level 2 descriptors for the six sections in Level 1. These may represent specific components or manufacturing steps such as finishes, assembly, etc. Figure 3 shows a segment of Level 3 for "control".

Continuing the level breakdown, Figure 4 shows a parts classification, which, at Level 6, begins to reflect the makeup of components, thus allowing for cost effects due to materials, size, etc. Along this same line, Figure 5 shows the variations in performance requirements for a transistor which can be accommodated and cost differences shown.

Figure 6 shows the pie chart method to be used for illustrating costs and highlighting cost drivers. This system depicts each part cost as a fraction of an assembly cost (graphically as a slice of a pie) which is likewise a fraction of a larger assembly cost and then a fraction of a complete missile cost. Each part cost can be graphically depicted as a portion of the total missile cost and compared to all other similar level part costs. Cost drivers then stand out as the largest slices of the pie.

The major references used for methodology development have been mentioned earlier. Appendix C contains a detailed reference list of pertinent documents received in this program.

5.0 METHODOLOGY DESCRIPTION

This missile cost driver methodology has four features. These are:

- (1) Parts Classification System
- (2) Parts Coding System
- (3) Data Storage and Display Methodology
- (4) Data Acquisition System.

Each is described and its unique features discussed below. The details of how these systems are integrated to determine missile cost drivers and perform other tasks are described in Section 6.0.

5.1 Parts Classification

The parts classification is a cataloging system for all the parts in a small missile air vehicle. Each part can be located in the system by its description and function.

As the tree expands, descriptors represent functions such as "propulsion" or "guidance". The succeeding levels become more specific and name the types of parts. These levels can then be characterized as separated by type with a similar function. For example, the functional section "Mechanical Drives" is divided into "Shafts", "End Connectors", "Linkage", and "Bearings". These parts all are related by the function of producing change in position by mechanical means but are separated according to the type of part needed to perform their function.

The lower levels further divide the types of parts by their characteristics. These are the last breakdown levels in the parts classification system. Each type of part such as "Fittings" in the functional section "Plumbing" are further divided by "Material" and "Size". This further breakdown allows for a variation in price of the size type part but made of a more expensive material or in a larger size.

This description has been necessarily vague as to the exact levels which are separated by function, type, or characteristic. Because of the variety and varying complexity of the parts, the breakdown does not

contain the same number of levels for each part. Even the simplest parts, however, have one level which fits each of the breakdown areas.

The current parts classification system has concentrated on the electronics area due to the large number of parts and because electronics are a known cost driver. Other areas have also been classified extensively but not to the same extent as the electronics area.

The classification system and the coding system (described in the next section) are easily adaptable to changing requirements of the methodology. For example, if a new type of actuator is invented and used in a missile, it can be added in as another section merely by expanding the tree and coding it with an unused number in the proper level.

5.2 Coding System

5.2.1 Description

A coding system was developed to give examples of the programmer/computer interaction in the description of the uses of the methodology (see Section 6.0). It is not intended to be an optimum system but shows what can be done and its advantages. The actual coding system used by the Army is dependent on several unknown factors such as the computer system and its software.

The code consists of three sections which make up a complete code number for any missile part. These are:

- (1) Missile Code
- (2) Part Code
- (3) Characteristics Code.

The missile code consists of two letters which describe each missile. The codes are:

- HELLFIRE -- HE
- TOW -- TO
- DRAGON -- DR
- STINGER -- ST
- REDEYE -- RE.

The part code is made up of 4-digit numbers. Each number represents a separate word in the part classification. Where words are used in two or more places, the same number is used to allow retrieval of all of those parts in the missile. For example, "Fairings" are cataloged in five locations but each location can be retrieved by using "1200".

The code numbers can be combined to designate the precise part in the breakdown. For example, the "Fairings" section of the "Structural System" is coded "1000 1200". The "1000" means "Structural Systems" and the "1200" means the "Fairings". Each word in the breakdown has its 4-digit code number printed next to it in Appendix A, "Parts Classification and Coding System". Figure 7 shows the breakdown of the electronics system and the 4-digit code number for each area.

The characteristics code consists of two parts. The first is a 2-digit number which designates the characteristic area such as material (Code 01), length (07), collector current (31), time constant (60), and transmittance (81). The second part designates the characteristic element for that area with a 3-digit number. For example, aluminum is coded 002, formed plate is 145, .001-.015 inches is 227, and so on. Thus, to designate a specific characteristic for a part, the two codes are combined to form a 5-digit number. Some of these are:

- Material-Silicone = 01027
- Power Source-Electrical Actuator = 17357
- Word Capacity=16K = 48673
- Burn Time-<30 sec. = 77941.

The codes for the characteristics are contained in Appendix A. The first part of Appendix A lists the codes for the characteristic areas and the second lists each area with its characteristic elements and their codes. Each is in numerical order according to area. The elements are coded from lowest to highest for numerical elements and randomly for word elements.

The complete coding, then, is a combination of these three codes. The following example shows the code for a typical part with each code associated with each word. The slash is used to separate the part code numbers from the characteristics code numbers. A decimal point or other mark would work equally well.

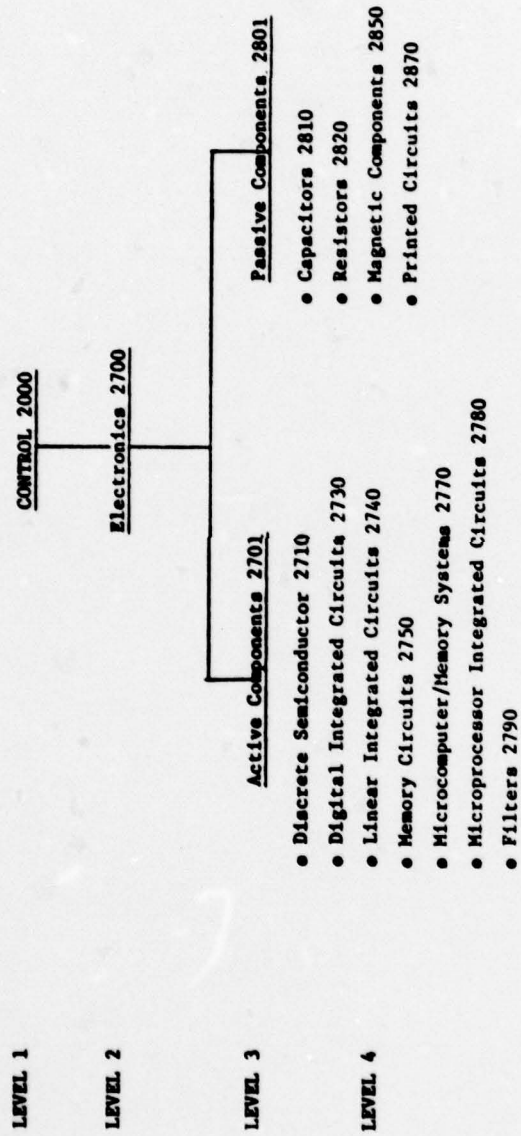


FIGURE 7. ELECTRONICS BREAKDOWN WITH 4-DIGIT CODE NUMBERS

HELLFIRE,	GUIDANCE,	ELECTRONICS,	ACTIVE COMPONENTS,
HE	3000	2700	2701
MEMORY CIRCUITS,	RANDOM ACCESS MEMORY-POLAR,		
2750	2751		
DIVIDER,	QUALITY-HIGH,	BIT CAPACITY-16K,	ACCESS TIME-<400S
/	40616	43673	44685

The complete code is:

HE30002700270127502751/406164367344685

5.2.2 Advantages

The advantage of this type of coding system is that it is useful in retrieving data from a breakdown tree such as the parts classification. The 4-digit number for each word allows the programmer to use one number when he wishes to retrieve information on one type of part. Then, by adding more numbers, he can become as specific as he likes in designating the part or parts he would like to retrieve.

For example, all the parts in the data bank made of steel can be retrieved by searching for 01001. Then all the parts in the HELLFIRE missile made of steel would be HE/01001. The steel parts in the structural system of the HELLFIRE missile would be HE1000/01001. The computer would compare that code with each code in its data bank and retrieve all parts with HE, 1000, and 01001 included, as a portion of their codes. Any code used to review the data should be able to manipulate it in a similar fashion in order to allow the methodology to be used to its fullest extent.

The coding numbers have been assigned to words, areas, and elements in a fairly systematic fashion. The first breakdown levels have simpler numbers while the lower levels are more complicated. For example, control is 2000 while a fixed, nonlinear varistor is 2829.

The numbers have been assigned so that each area has spare numbers for additions. The characteristic areas are from 1-86 leaving 14 numbers unfilled. Each area has a range of numbers which designate elements that apply. Some elements are applicable to more than one area and retain the first number designated to them throughout the coding system.

5.3 Data Storage and Display

The third feature of the methodology is the system for display of cost information. The pie chart depiction of cost distribution has already been described, and the intent would be to develop these as shown subsequently in Section 6.0 of this report.

For future considerations, we have listed below and compiled in Figure 8 the type of data format that might ultimately be used in the system to develop a total history on each part. Input for much of this compilation would have to come from contractors, subcontractors, and component suppliers.

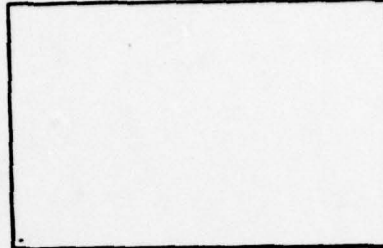
Cost factors which might be obtained to develop part characterization are:

- (1) The physical dimensions of the part--an isometric drawing including overall dimensions, weight, and tolerances
- (2) The specific material alloy used, such as aluminum 6061-T6, or an accurate material analysis
- (3) Other materials which have been used to make this part and the resulting difference in cost
- (4) Any heat treatment to improve physical and mechanical properties
- (5) The specifications or characteristics of the parts such as wattage, time constant, output range, etc.
- (6) Any chemical process such as painting, priming, or anodizing
- (7) A list of the basic fabrication steps
- (8) Whether the method is a new emerging process or an old, familiar process
- (9) Other methods which have been used to fabricate this part and the difference in cost

NAME:
 CODE:
 TOTAL COST:
 PURCHASED OR FABRICATED:
 SCALE:
 DIMENSION UNITS:
 WEIGHT:
 TOLERANCE:
 REQUIRED FOR MISSILE:

DRAWING:

STANDARD MAN HOURS:



MATERIAL:

OPTIONAL MATERIAL:
 HEAT TREATMENT:
 CHEMICAL TREATMENT:
 SPECIFICATIONS:
 FABRICATION STEPS:

% CHANGE IN COST:

OPTIONAL METHOD:
 PART STATUS:
 TOOLING FAMILIES:
 COST BREAKDOWN

% CHANGE IN COST:

RAW MATERIAL: %
 RECURRING TOOLING: %
 NON-RECURRING TOOLING: %
 SUPPORT COSTS: %
 LEARNING CURVE UNIT:
 LOT SIZE:

% CHANGE IN COST:

OPTIONAL LOT SIZE:
 PRODUCTION RUN SIZE:
 OPTIONAL RUN SIZE:
 SET UP TIME:
 RUN TIME:
 DATES

% CHANGE IN COST:
 STANDARD MAN HOURS
 STANDARD MAN HOURS

COSTS COMPUTED:
 COSTS REPORTED:

FIGURE 8. DATA DISPLAY (BASIC PART)

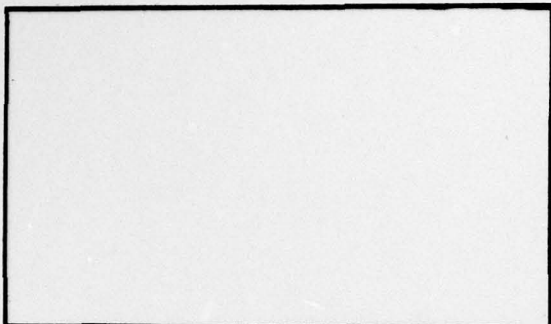
- (10) The part status--in production, a prototype, or a special one-of-a-kind
- (11) The tooling families used in this process
- (12) Whether the part was fabricated in-house or purchased
- (13) The percent of the total cost which is the raw material costs
- (14) The unit on the learning curve on which costs were based (usually 200)
- (15) The lot size
- (16) Other lot sizes used and the difference in cost
- (17) The production run size
- (18) Other run sizes used and the difference in cost
- (19) The set-up time per lot
- (20) The run time per piece
- (21) The percent of total cost which is the recurring tooling
- (22) The percent of total cost which is the non-recurring tooling
- (23) The date the costs were computed and the date costs were reported.

A possible contractor reporting system as seen in Figure 9 represents a significant extension of the HELLFIRE D to C reports now generated (as shown typically in Figure 10). Discussions of this proposed reporting system were held with Rockwell International-Columbus Division staff associated with HELLFIRE manufacture. Their critique indicated that this form should be condensed in size and requested only on the most expensive parts. It was also recommended that process definition, learning curves, and tooling cost information be excluded.

5.3.1 Data Display

The data display for an assembly will be quite similar to the one for a basic part (shown in Figure 8) but will include these changes:

- (1) MATERIAL--No material specification will be required for an assembly



DRAWING

NAME:

PART NO:

CODE NO:

REQUIRED FOR MISSILE:

REQUIRED FOR NEXT ASSEMBLY:

NEXT ASSEMBLY PART NO:

SCALE :

UNITS :

PURCHASED OR FABRICATED?

FABRICATION STEPS: (1)
(2)
(3)
(4)

OLD OR NEW?

OPTIONAL METHOD: (1)
(2)
(3)
(4)

% CHANGE IN COST:

HEAT TREATMENT:

CHEMICAL TREATMENT:

MATERIAL:

OPTIONAL MATERIAL:

% CHANGE IN COST:

SPECIFICATIONS:

PART STATUS:

TOOLING FAMILIES:

LOT SIZE:

OPTIONAL LOT SIZE:

% CHANGE IN COST:

PRODUCTION RUN SIZE:

% CHANGE IN COST:

OPTIONAL RUN SIZE:

FIGURE 9. DATA ACQUISITION FORM

LEARNING CURVE UNIT:

SET UP TIME:

RUN TIME:

TOTAL COST:

RAW MATERIAL: %

RECURRING TOOLING: %

NON-RECURRING TOOLING: %

SUPPORT COSTS: %

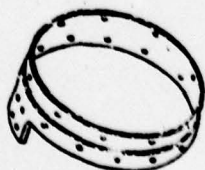
DATE COST COMPUTED:

DATE COST REPORTED:

FIGURE 9. (Continued)

<div style="border: 1px solid black; padding: 2px; display: inline-block;"> PRODUCT DESCRIPTION: <u>MISSILE</u> </div>		
PART NUMBER: <u>13006302</u>	PART NAME: <u>FRAME FWD CONTROL</u>	VBS NO. <u>11200</u>

QUANTITY PER NEXT ASSY: <u>1</u>	QUANTITY PER END ITEM: <u>1</u>
NEXT ASSEMBLY NAME: <u>CONTROL SECTION ASSEM.</u>	
NEXT ASSY PART NUMBER: <u>13008360</u>	
MANUFACTURE <input checked="" type="checkbox"/>	PURCHASE <input type="checkbox"/>
RAW MATERIAL: <u>7075-T6 AL. TUBING</u>	
<u>98-A-200/11</u>	
RAW MATERIAL TOLERANCE:	
PROCUREMENT QA REQMT'S:	
MANUFACTURING PROCESS:	
1) <u>LATHE</u>	
2) <u>MILL</u>	
3) <u>DRILL - TAP</u>	
<u>De-Burr - De-grease - Protective Coat</u>	
SET-UP HOURS	QUANTITY/RELEASE
MANUFACTURING TOLERANCE: <u>+ .000 - .005</u>	
IN-PROCESS QA REQMT'S: <u>Per Dwg</u>	
RESPONSIBLE ENGINEERS-	
DESIGN: <u><i>E. Schubert</i></u>	
PRODUCTION: <u>C. SHOEMAKER</u>	
QUALITY: <u>M. B. G. 14</u>	
DATE: <u>12/31/77</u>	
REV:	
REV:	



SCALE = $\frac{1}{2}$ IN. = 1 IN.

COSTS PER <u>1</u>
MATERIAL:
LABOR:
MISC. HARDWARE:
TOTAL:
2 OF WBS COST:
REALIZATION FACTOR
DTC COST REPORT & MFG. CODE

Form 434-C-46

6-77

REV. 12-77

FIGURE 10. EXAMPLE OF COST REPORTING FORM USED ON HELLFIRE MISSILE DEVELOPMENT

- (2) FABRICATION STEPS--This will be changed to "ASSEMBLY STEPS".
- (3) PART STATUS--This will be changed to "ASSEMBLY STATUS".
- (4) COST BREAKDOWN--Instead of "Raw Material" and "Tooling", the total cost will be broken down by the next level of assemblies or parts which make up the assembly. The support costs will still be included.

The display will not always have each area as shown in Figure 9. If the data are unavailable or not relevant, then the item will not be shown. The computer should also be programmable to display only a portion of the data to save time and space when only one factor is being reviewed.

5.3.2 Ground Rules

Some cost factors will be specified before the data is reported to standardize the reporting between contractors. These factors will be called "Ground Rules" and are listed below:

- (1) The total costs will include all hands-on-factory direct operations such as raw-stock, blank preparation, forging, heat-treatment, metal removal, priming, washing, tagging, and storing.
- (2) The total costs will also include all support function modifiers such as planning, quality control, testing, inspection, etc.
- (3) The total costs of assemblies will include the cost of joining, fastening, and other assembly operations.
- (4) The units used to describe the parts will all be S.I. units.
- (5) All costs will be reported in standard man-hours or a percent of the total part cost.

5.3.3 Data Storage

The data will be stored for each missile part and retrievable by specifying the specific code for that part. Data for similar parts will

be retrievable as a group to allow comparisons to be made. Each part or junction of the tree will also have a data set that can be retrieved. This will allow cost comparisons of assemblies from different missiles.

6.0 USE OF THE METHODOLOGY

It is the intent of this section to demonstrate what the methodology could do if developed. As already discussed, it provides for cost-driver identification through cost reporting and establishment of a parts classification system.

6.1 Cost-Driver Identification

A primary use of the methodology is to determine the cost drivers in a missile system. The technique used to determine the cost drivers is demonstrated in Figure 11. User input indicates the areas and descriptors of interest and the computer display shows the program output.

6.2 Cost Assessment of Future Missiles

The methodology could also be used to estimate the cost of new missile components by comparing portions of the new design with similar portions of current missiles whose costs are known. More accurate predictions of a future missile's cost can be made because a more detailed comparison of parts and their costs is possible. Further, comparisons with parts of many different missiles can be made with equal ease instead of trying to make the cost prediction from one or two current missiles. An example of how this technique might be used to examine costs of a designed missile is illustrated in Figure 12.

In this example, three types of fairings designs are available in the system so the investigator can compare his concept with several designs and get at least some baseline data on that design which is closest to his requirement.

6.3 High Cost Ratio Between Parts of Varying Size, Value, Material, Etc.

Potential areas for manufacturing technology development could be suggested based on the difference in cost of similar parts of different

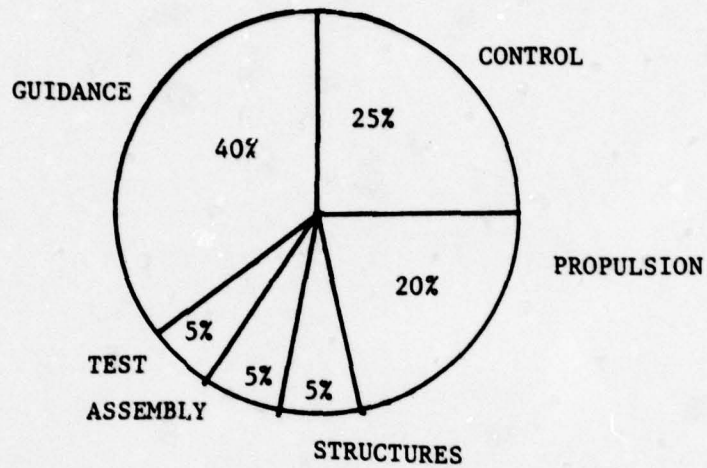
User Input

Computer Output

1. Identify Missile
"HELLFIRE"

1.

HELLFIRE (HE)



2. Identify Area
"GUIDANCE"

2.

GUIDANCE (HE3000)

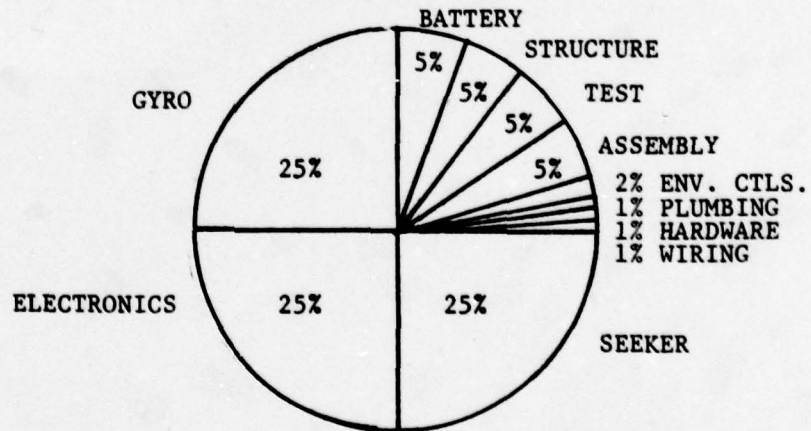


FIGURE 11. COST-DRIVER IDENTIFICATION

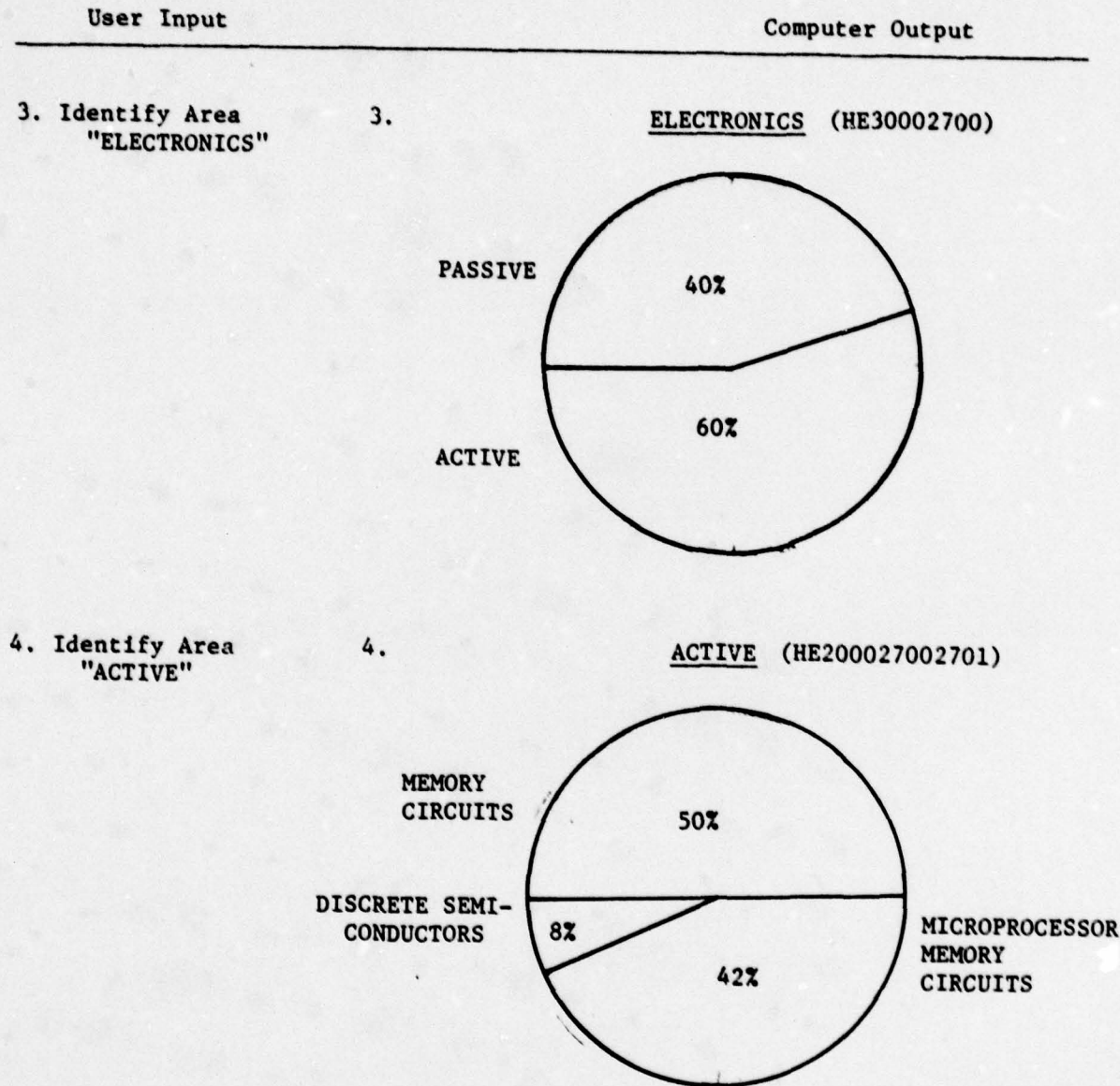


FIGURE 11. (Continued)

User Input

Computer Output

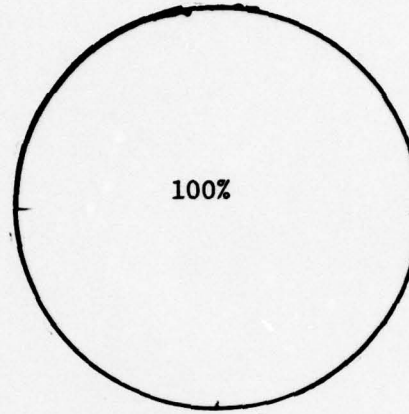
5. Identify Area
"MEMORY CIRCUITS"

5.

MEMORY CIRCUITS (HE3000270027012750)

RAM

100%



6. Request Part
Characteristics

6. RAM CODE (HE30002700270127502751/406164367344
685)

Characteristics:

Cost: 2.3 Manhours
Quality: High
Bit Capacity: 16K
Access Time: <400s

Cost Factors:

Production Quantity: 50,000
Lot Size Quantity: 100
Time Frame: 6/75 - 8/78

FIGURE 11. (Continued)

Computer Output

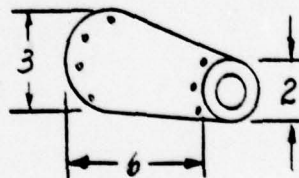
1. Possible locations and code

- Structural Systems, Code 1000
- Control, Structures,
Code 20001200
- Guidance, Structures,
Code 30001200
- Propulsion, Launch Motor, Structures,
Code 400041001200
- Propulsion, Flight Motor, Structures,
Code 400042001200

MATERIALS 01

- Steel - 001
- Stainless - 003
- Aluminum - 002
- Composite - 004
- Plastic - 005

FABRICATION METHOD

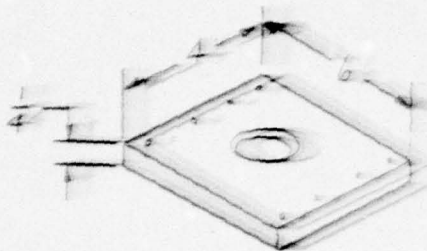


- **Missile:** HELLFIRE
- Code No.** HE10001200/01002
- Material:** Aluminum
- Fabrication:** Rolled & Welded

FIGURE 12. COST DATA ACQUISITIONS FOR DESIGN CONSIDERATIONS

User Input

Computer Output

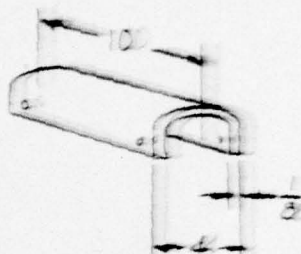


• Missile: SPINGER

Code No. ST10001200/01002

Material: Aluminum

Fabrication: Formed Plate



• Missile: TOW

Code No. T010001200/01002

Material: Aluminum

Fabrication: Rolled

4. Part Closest to
Designed Part
"Code T010001200/01002"

4. Characteristics and Cost Factor Data
on Selected Part

• Missile: TOW

Part Code No. T010001200/01002

CHARACTERISTICS

Cost: 2.73

Material: Aluminum

Fabrication: Rolled

Weight: 1.8 lbs

Cost Factors

Production Quantity: 500

Lot Size: 25

Time Frame: 6/78 - 8/78

FIGURE 12. (Continued)

size, material, configuration, etc. For example, suppose the cost of three fairings, 1-, 2-, and 3-feet long, are compared. The 1-foot fairing costs \$2, the 2-foot fairing costs \$4, but the 3-foot fairing costs \$15. One of several possible reasons for this difference is that some step in the manufacturing process for the large fairing is more costly than that used for the smaller fairings. A manufacturing technology project which upgrades the more efficient process or devises an alternate fabrication method for use with larger parts would reduce the cost of the large fairings.

APPENDIX A

PARTS CLASSIFICATION TREE
AND CODING SYSTEM

NOTES FOR PARTS CLASSIFICATION TREE
AND CODING SYSTEM

1. Each word in the tree is given a separate four-digit number.
2. No specific order is used but the simplest numbers are reserved for the highest breakdown levels in the tree.
3. Coding for a specific missile part is always preceded by its missile designator letters:

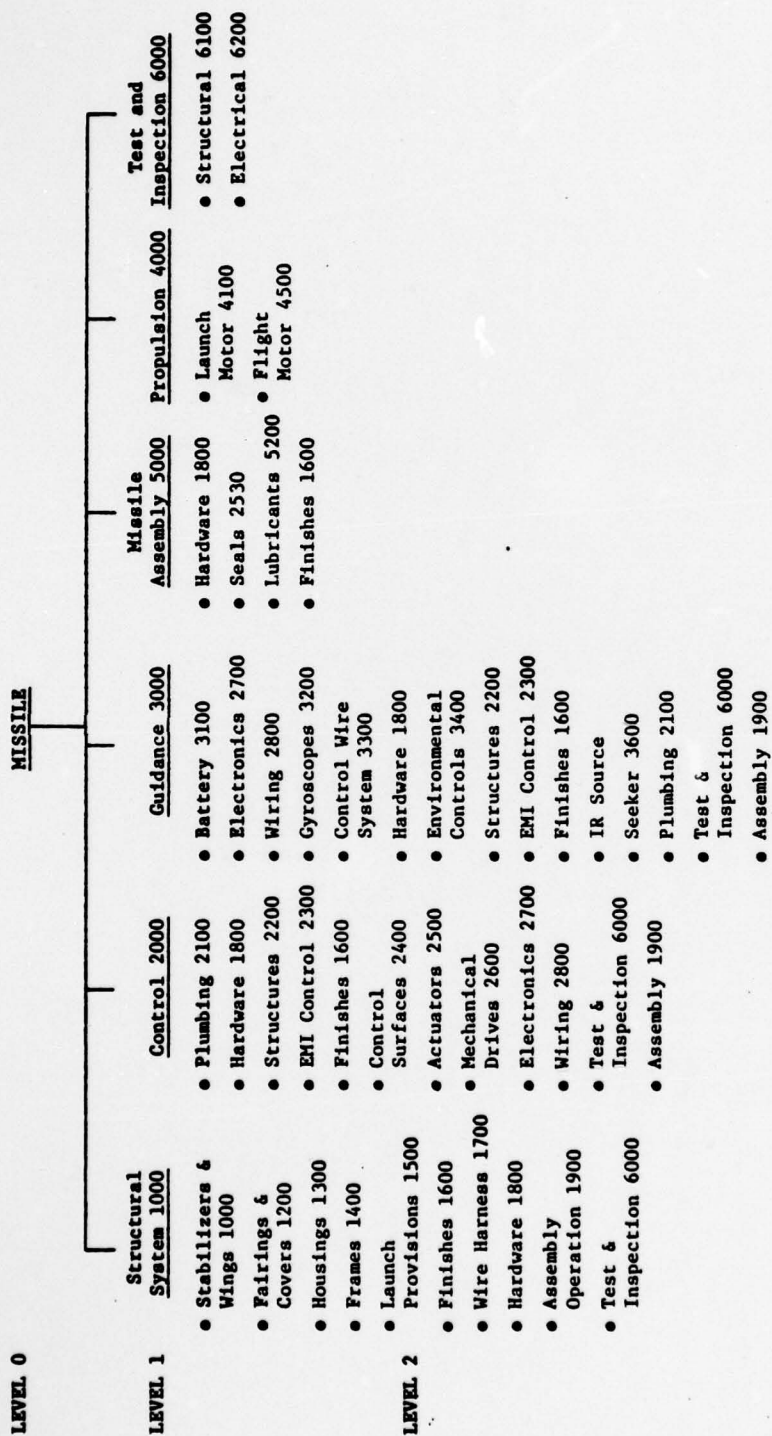
HELLFIRE -- HE

TOW -- TO

DRAWN -- DR

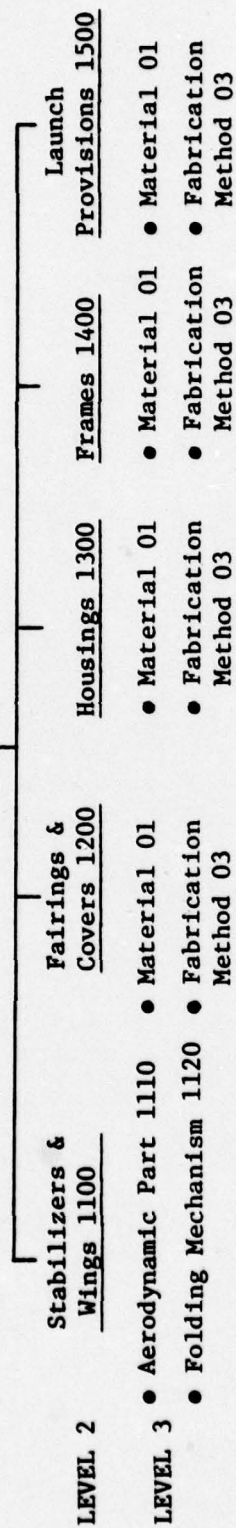
STINGER -- ST

REDEYE -- RE



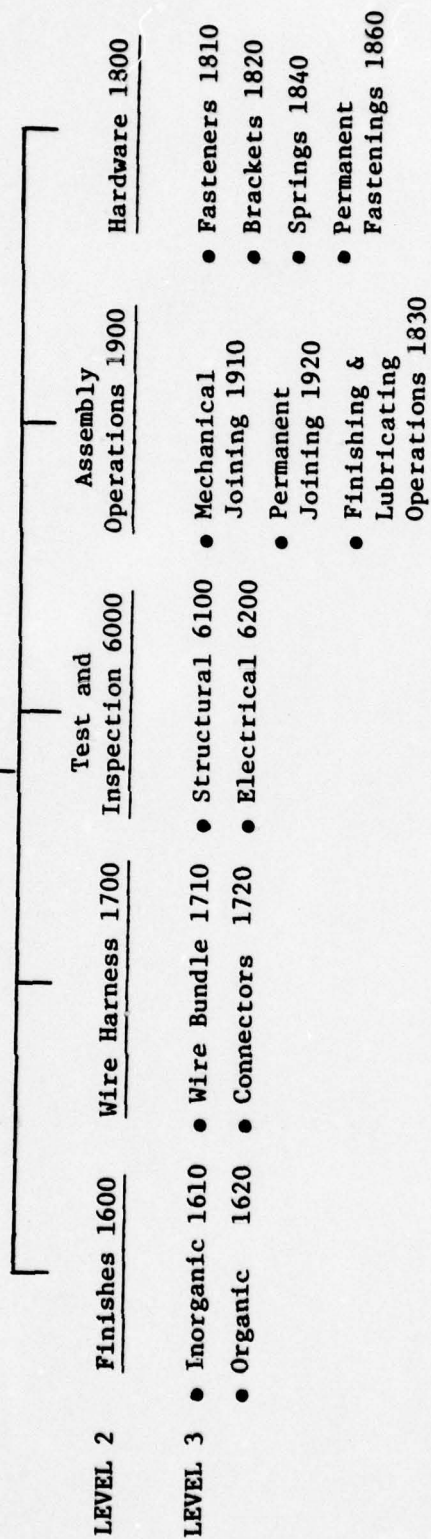
LEVEL 1

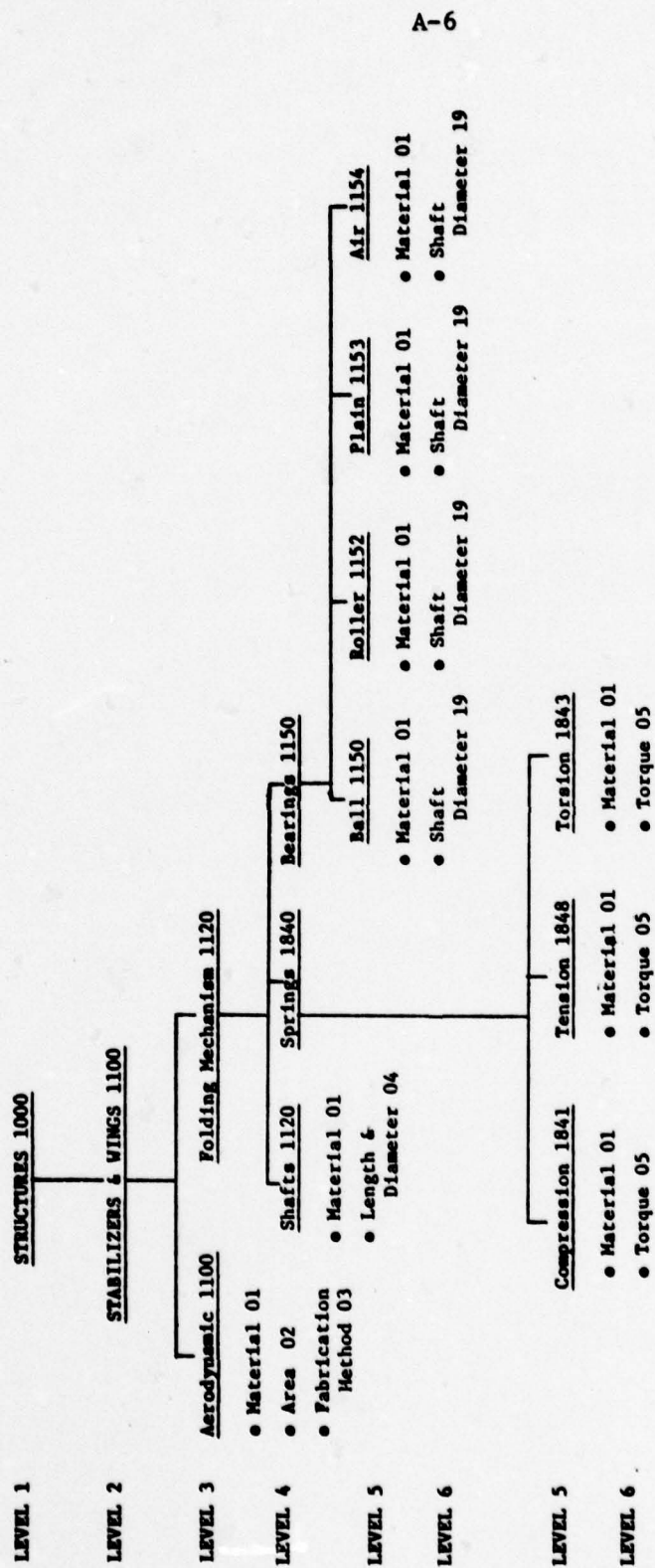
STRUCTURAL SYSTEM 1000



LEVEL 1

STRUCTURAL SYSTEM 1000





STRUCTURAL SYSTEM 1000

FINISHES 1600

Organic 1620

Inorganic 1610

Chemical

Conversion 1612

Metallc 1611

Thermosetting 1621

Thermoplastic 1622

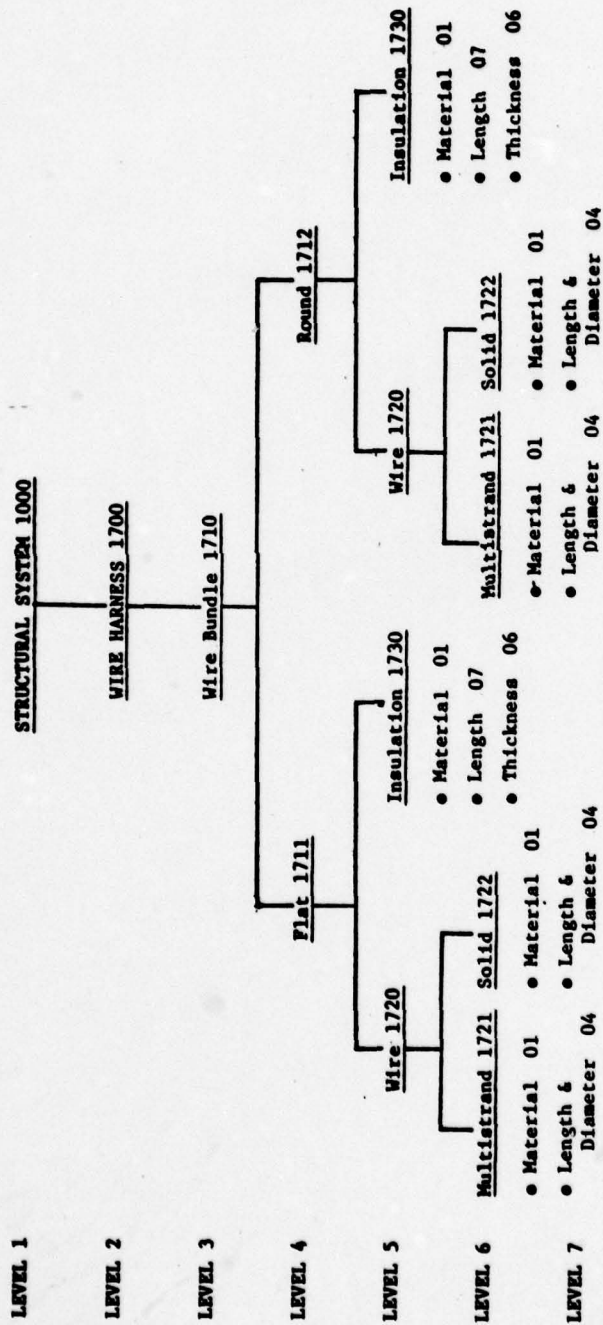
Elastomer 1623

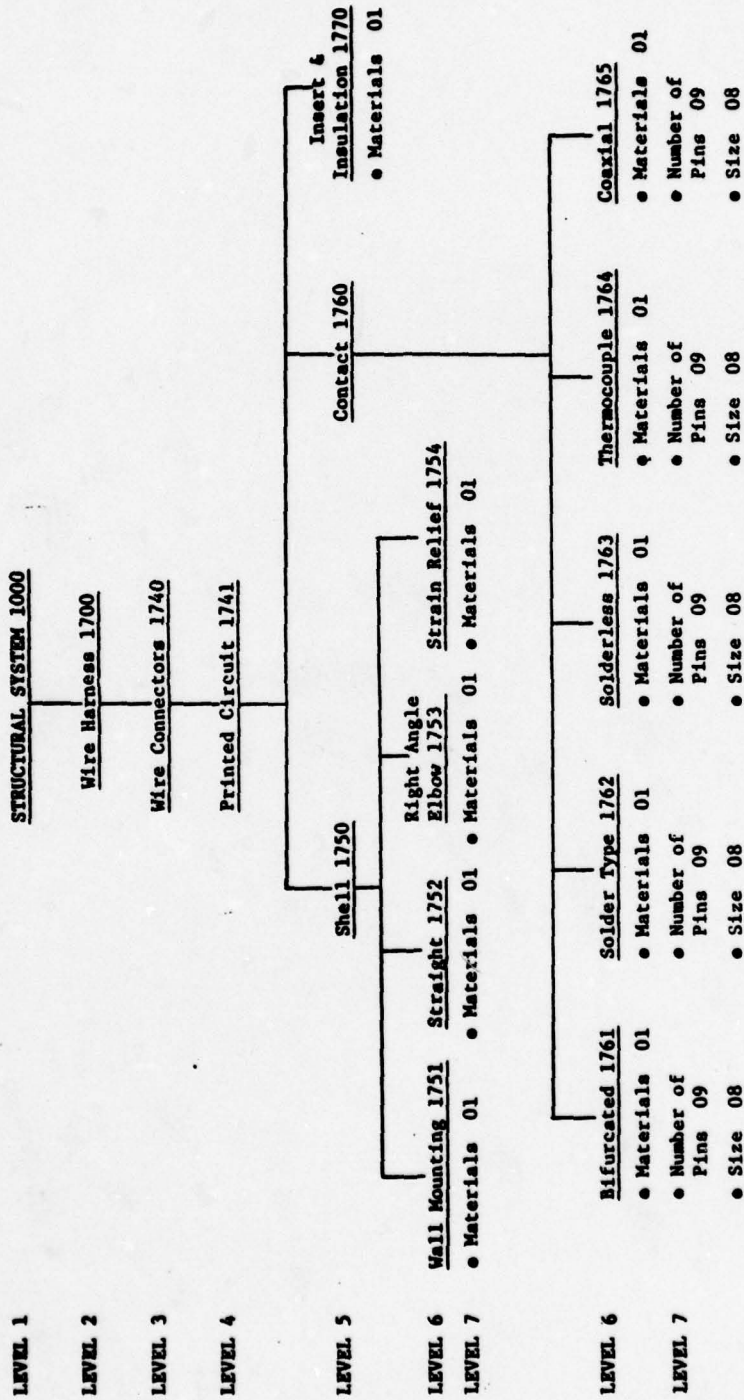
- Fabrication Method 03
- Material 01
- Area 02
- Thickness 06

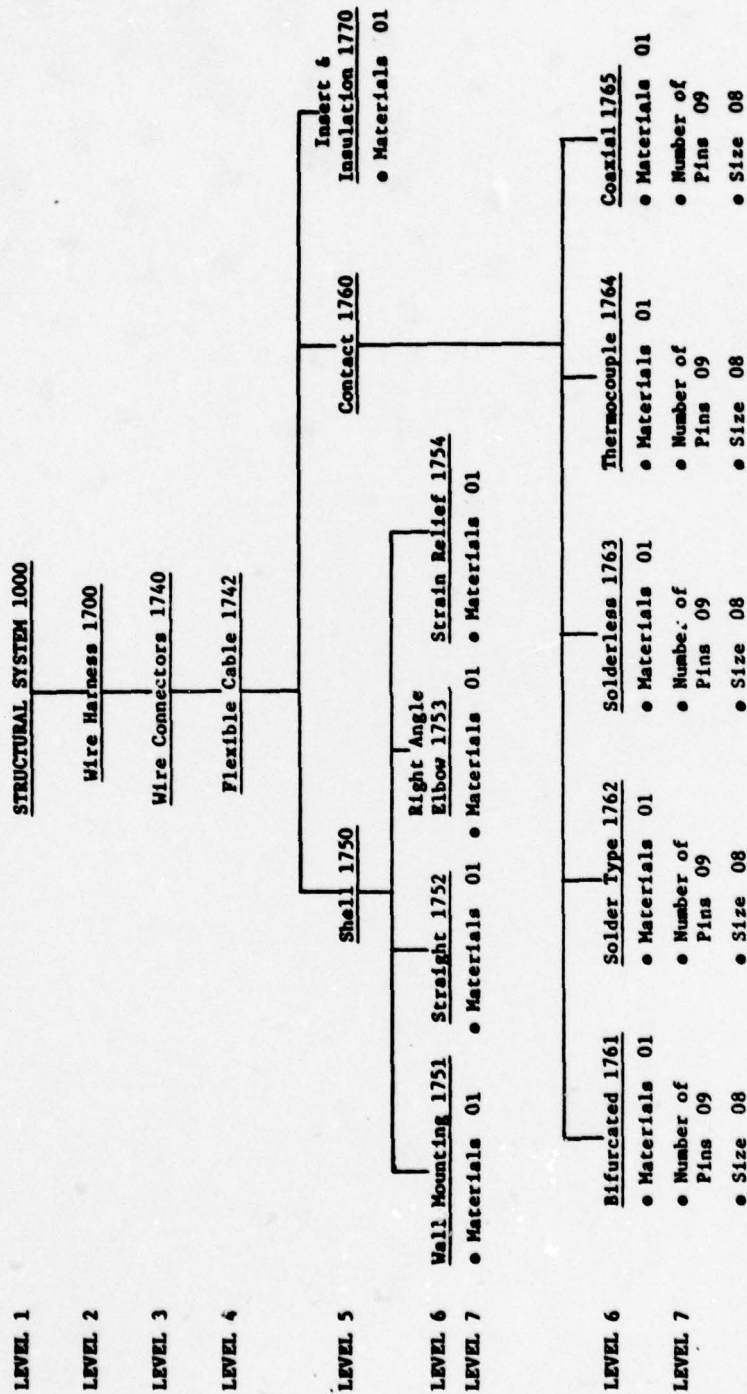
- Material 01
- Area 02
- Thickness 06

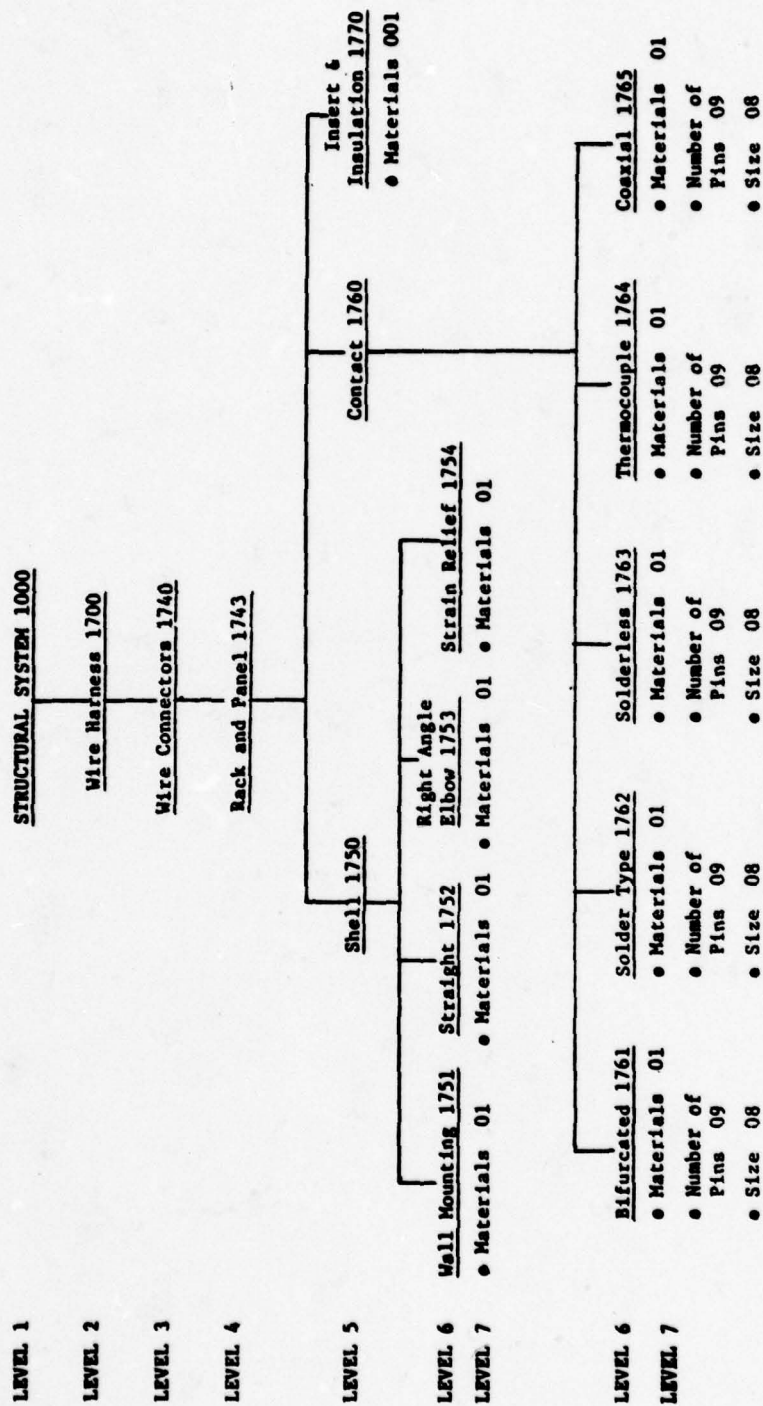
- Material 01
- Area 02
- Thickness 06

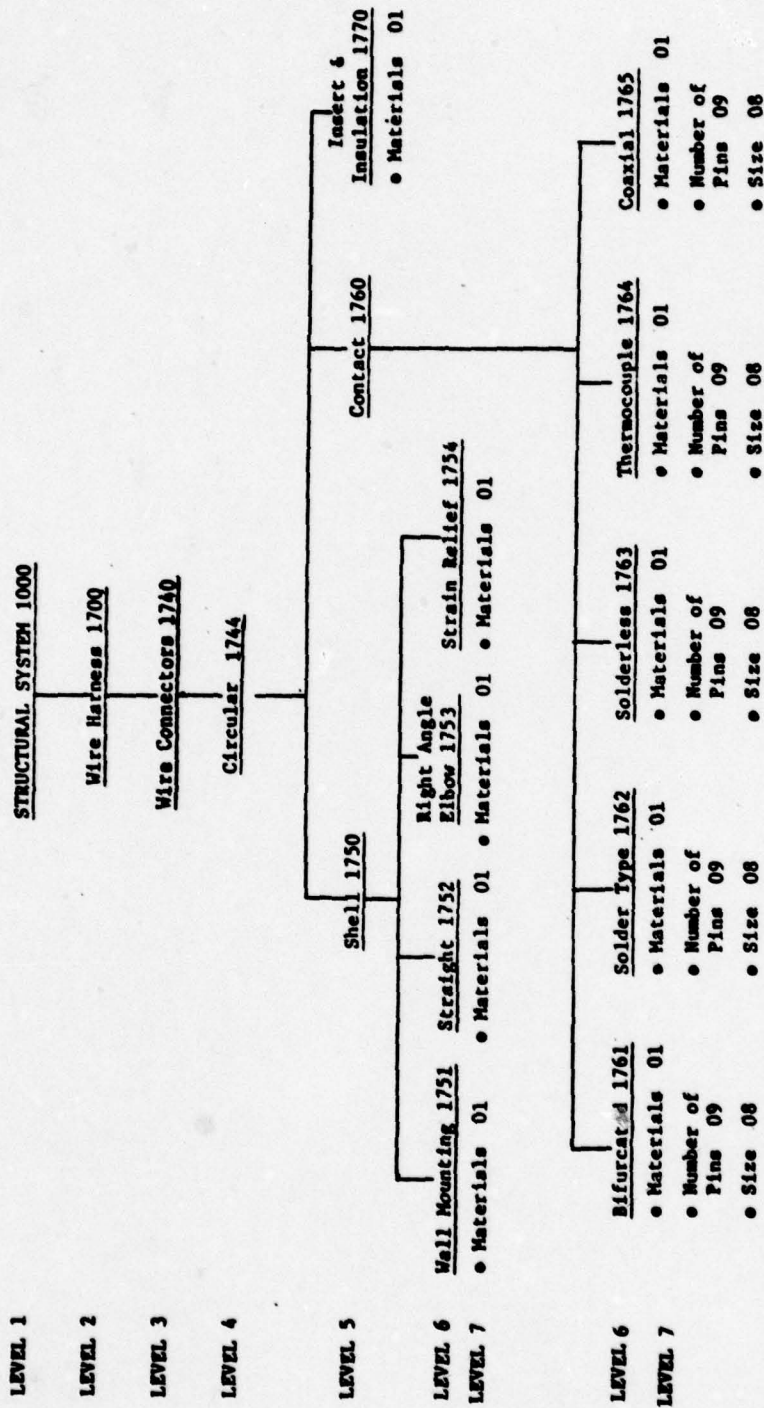
- Material 01
- Area 02
- Thickness 06











LEVEL 1

LEVEL 2

LEVEL 3

LEVEL 4

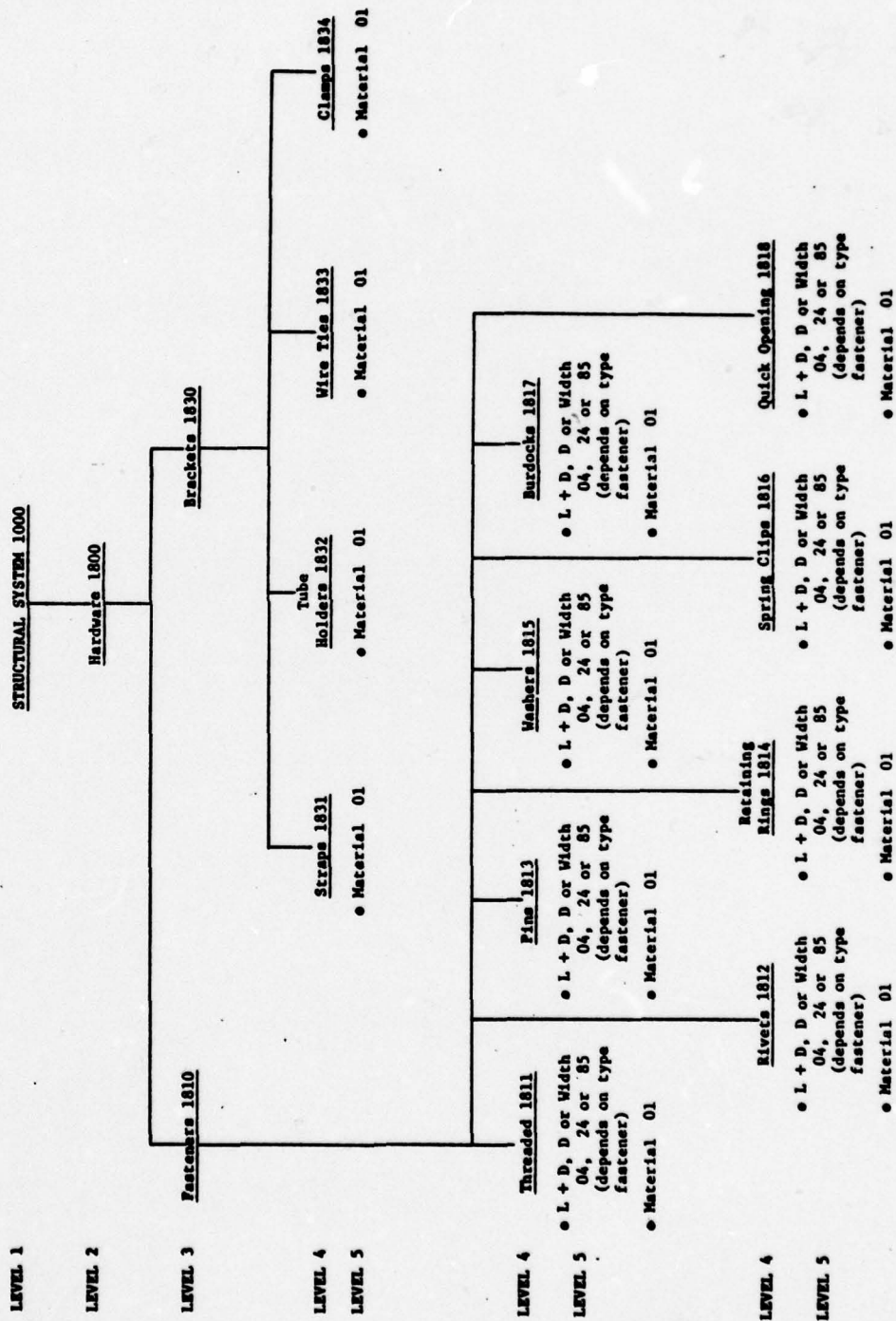
LEVEL 5

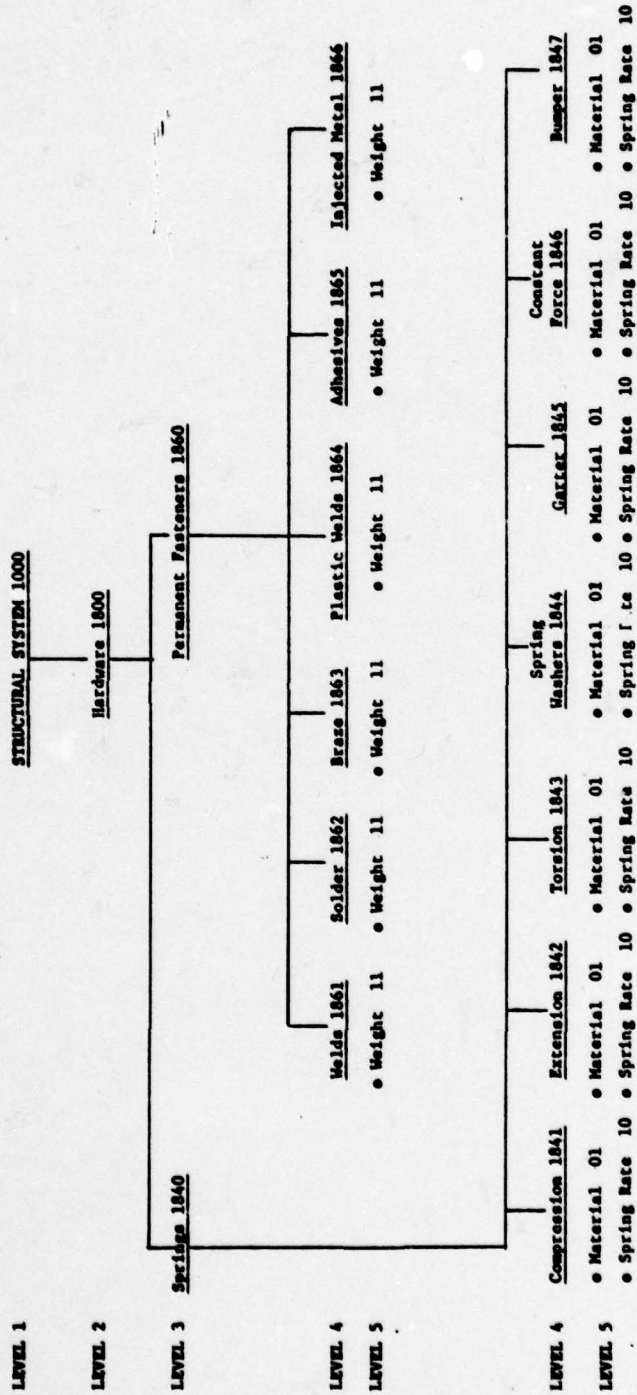
LEVEL 6

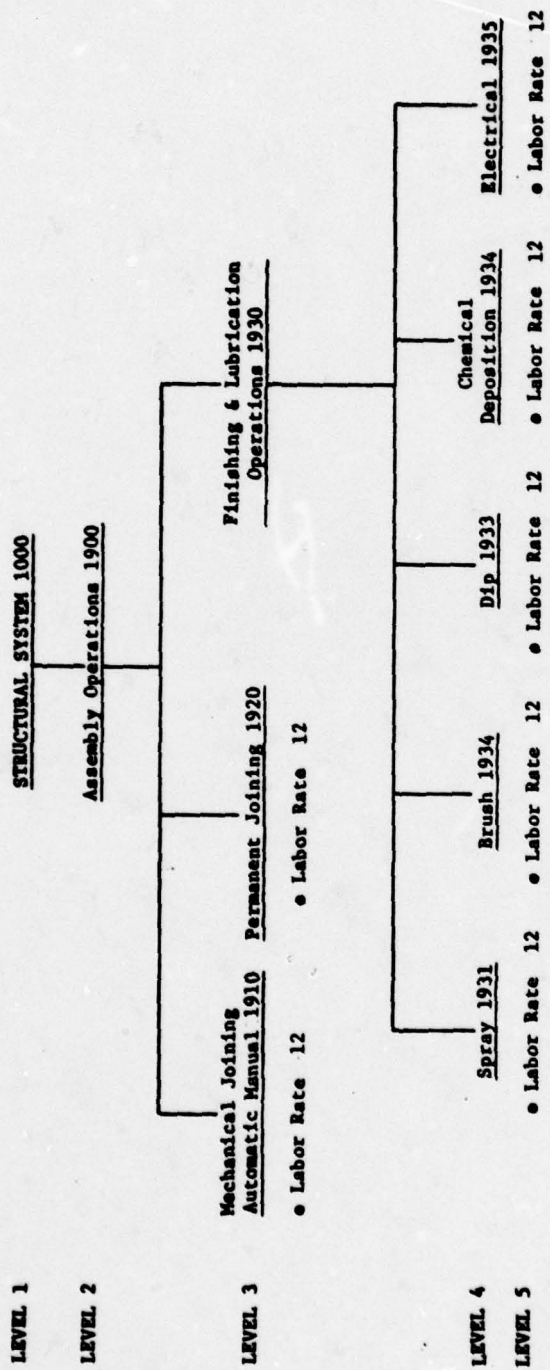
LEVEL 7

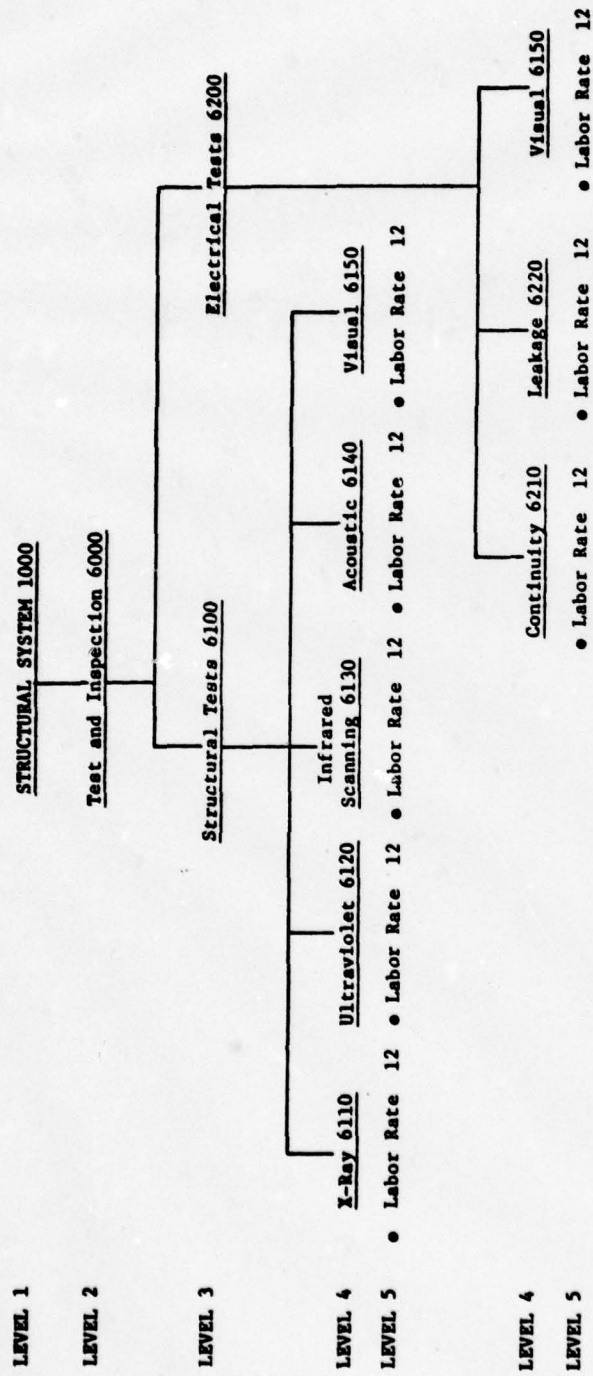
LEVEL 6

LEVEL 7

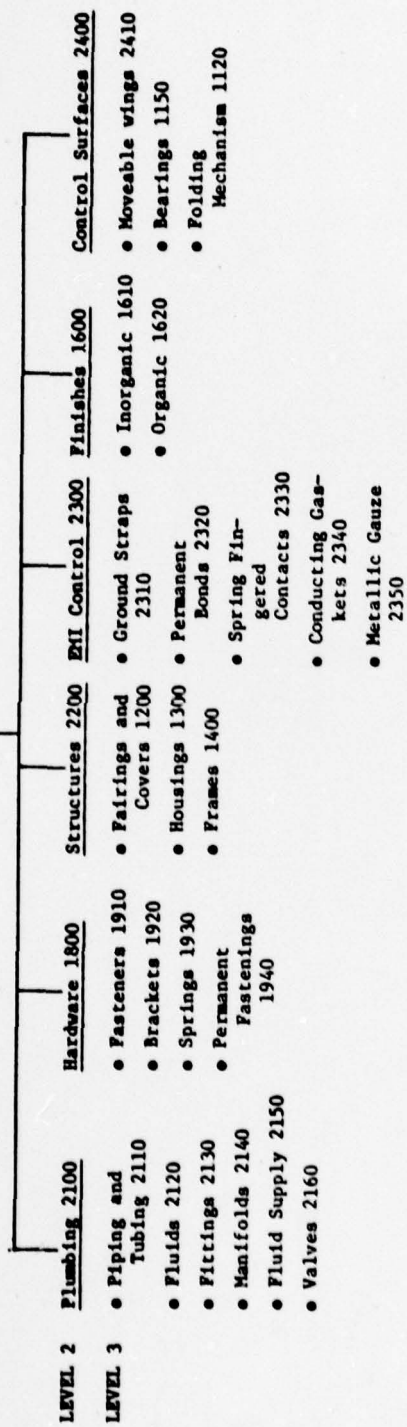


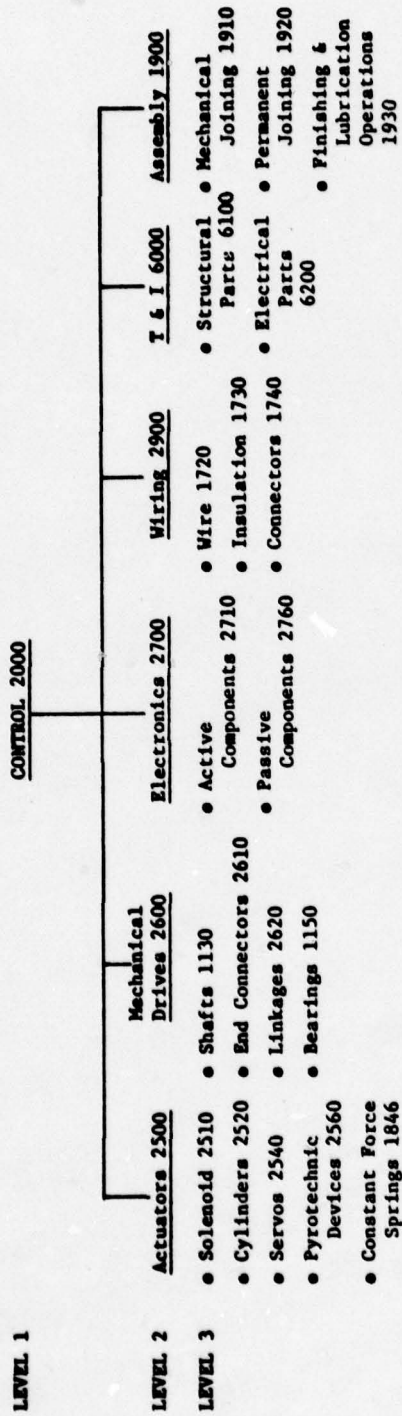


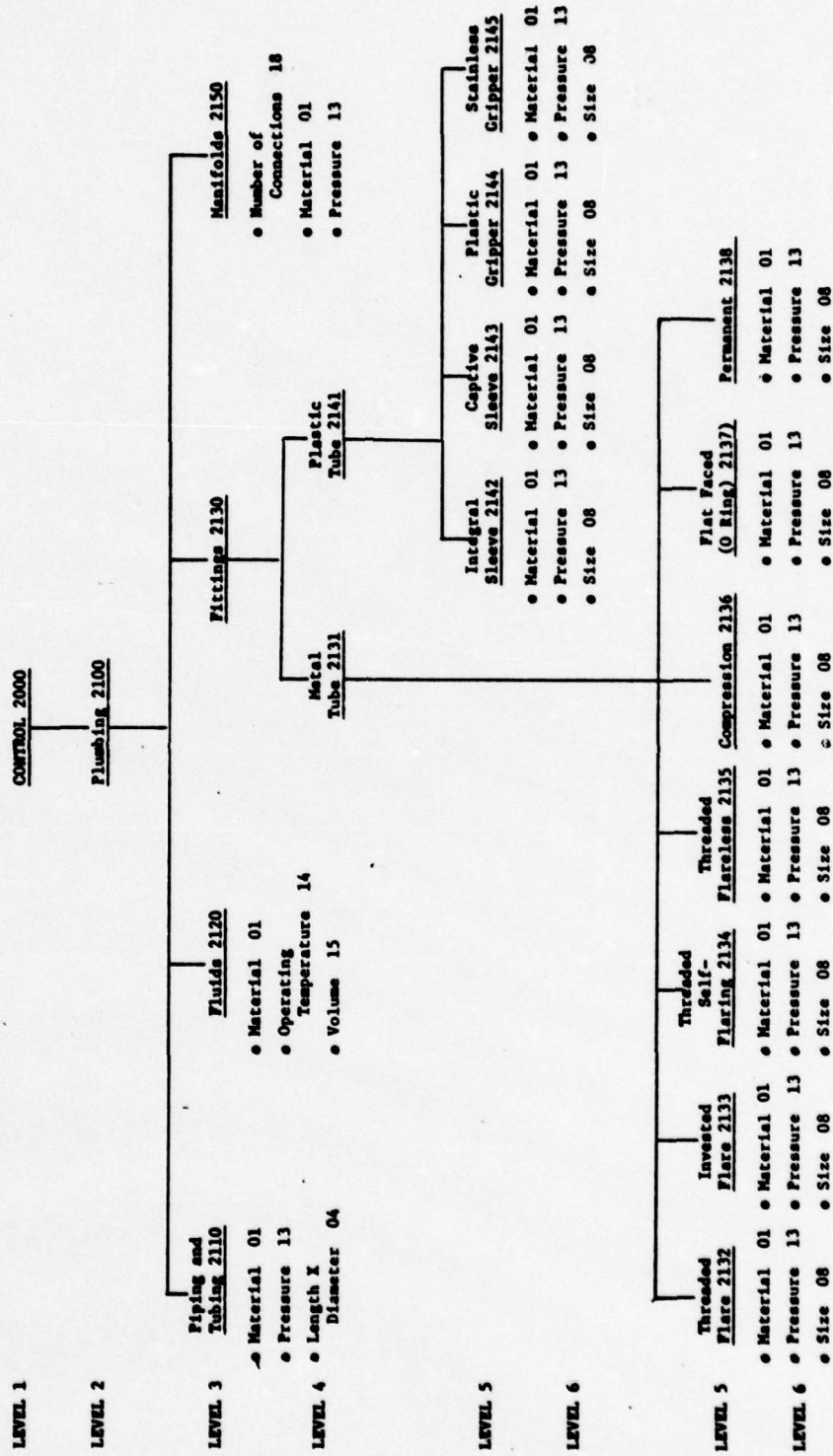


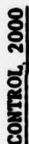


LEVEL 1

CONTROL 2000







LEVEL 1

LEVEL 2

Hardware 1800

(See 1800)

Structures 2200

EMI Control 2300

LEVEL 3

Frames 1400

•

Material C

LEVEL 3

Permanent Bonds 2320

Conducting
Caskets 2340

Metallic Gauze 2350

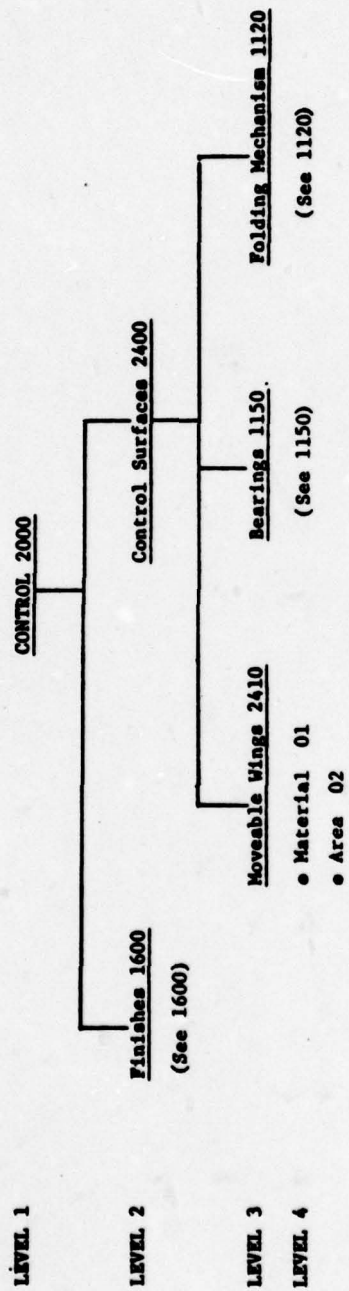
LEVEL 4

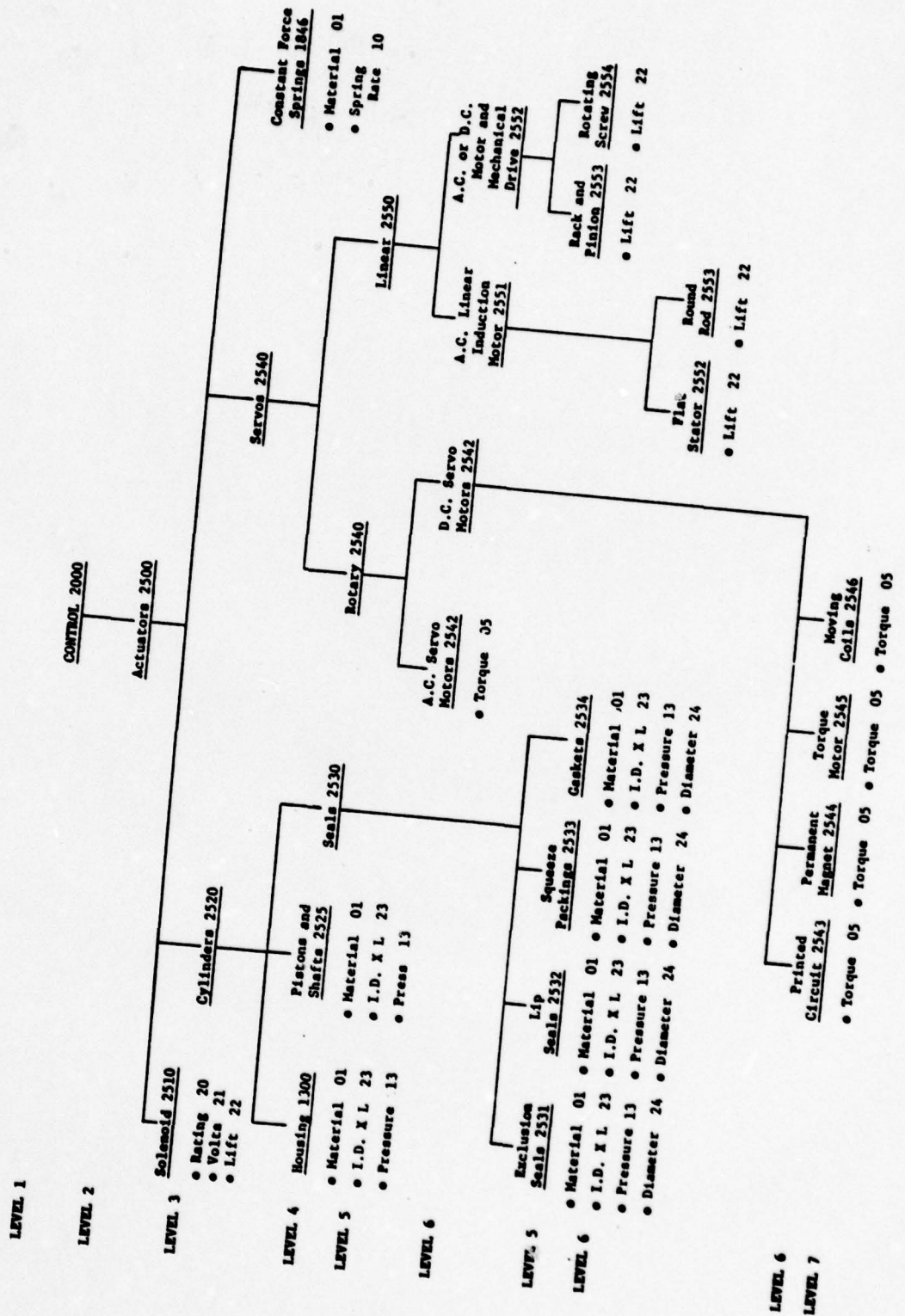
● Material 01

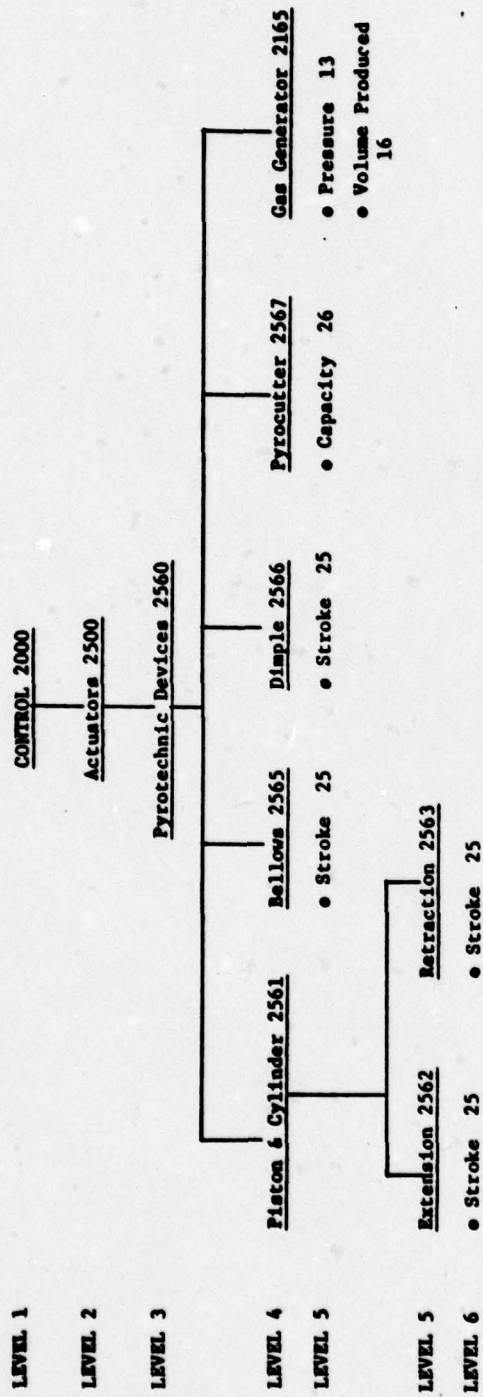
aterial · 01

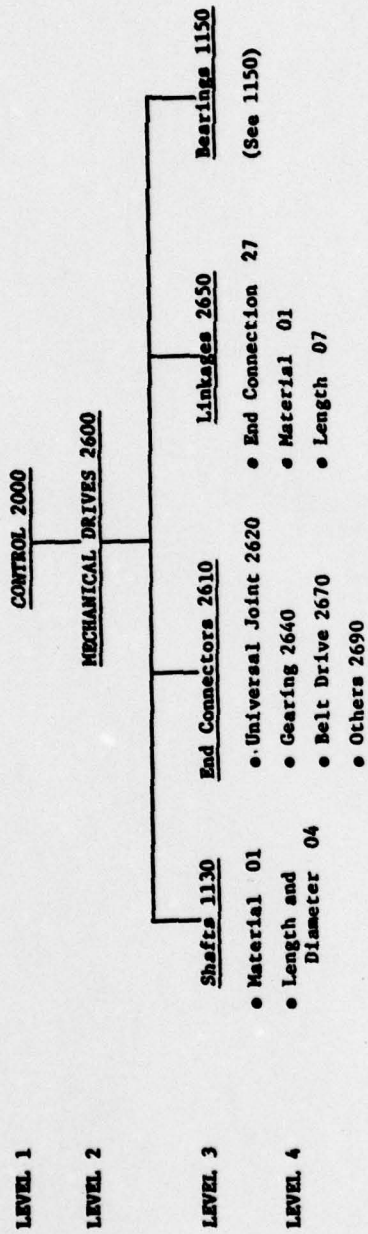
Material 01

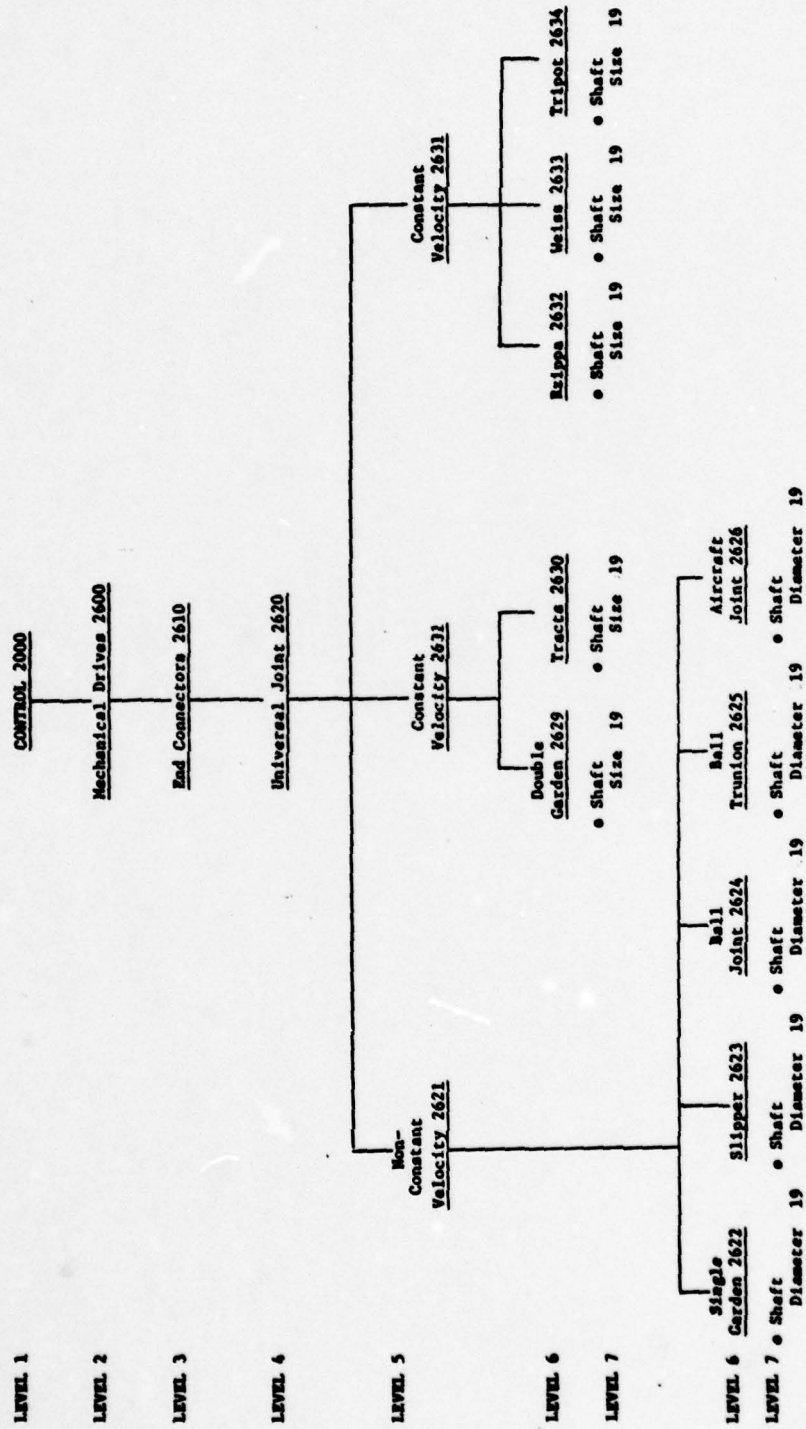
● Material 01

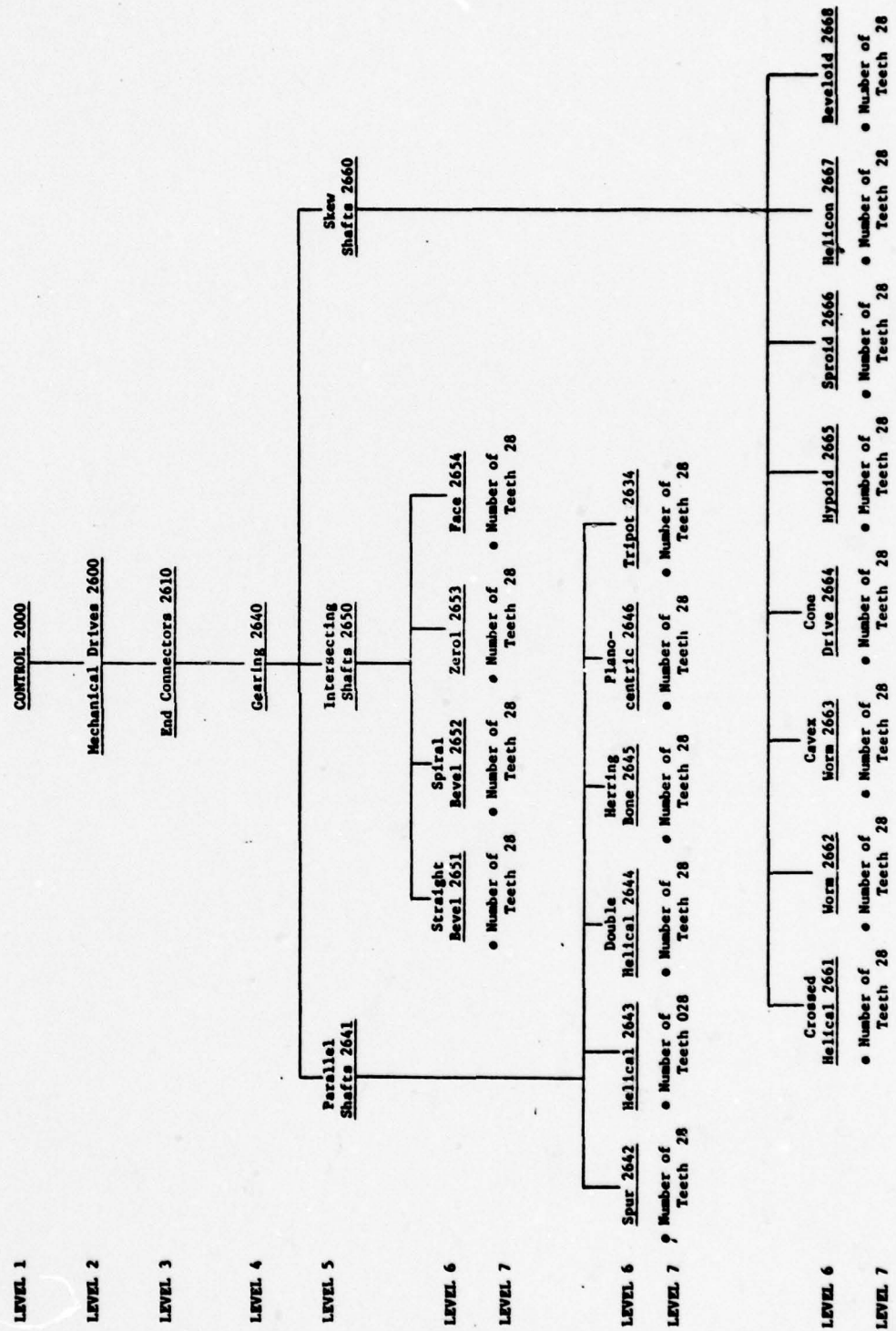


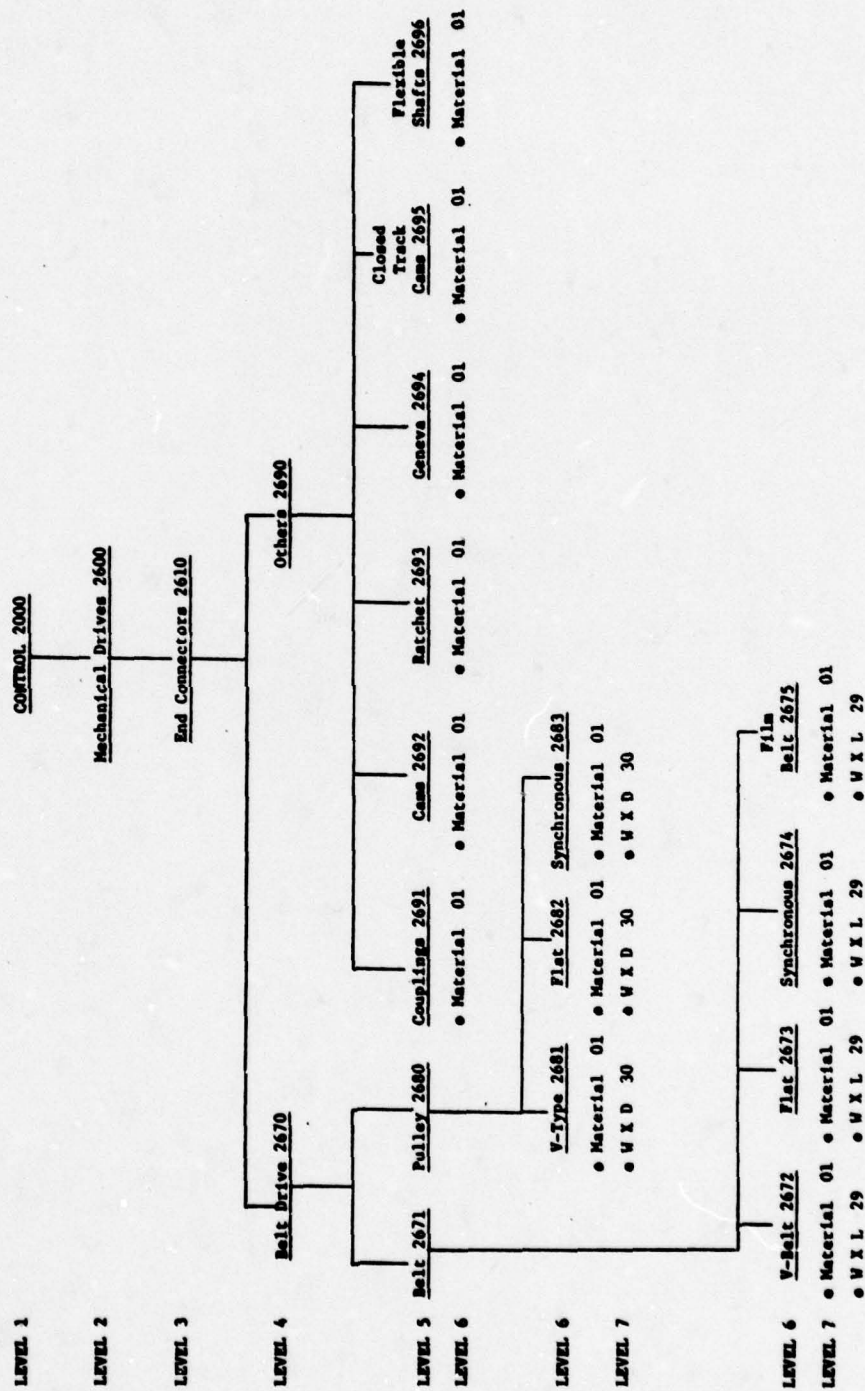


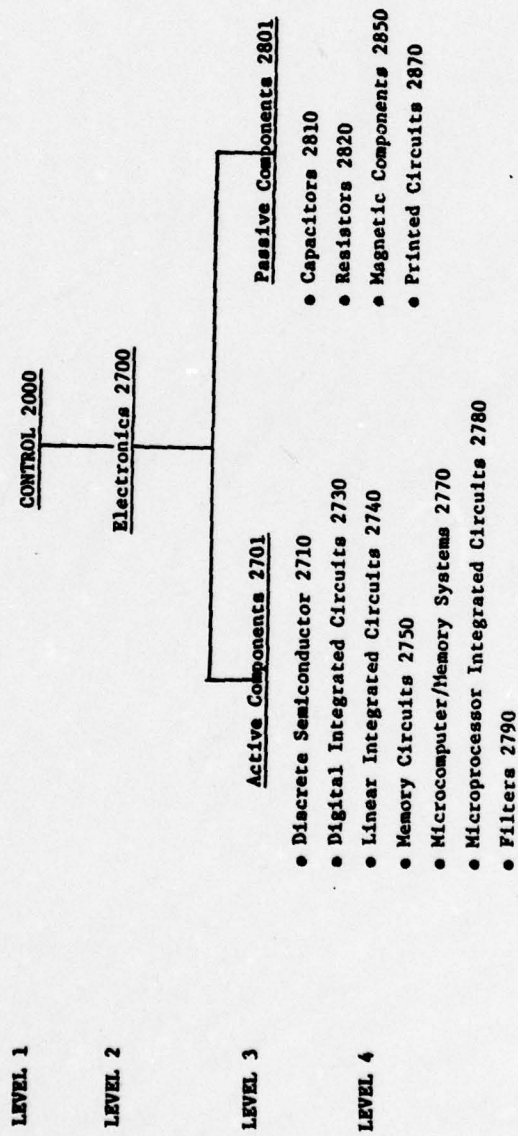


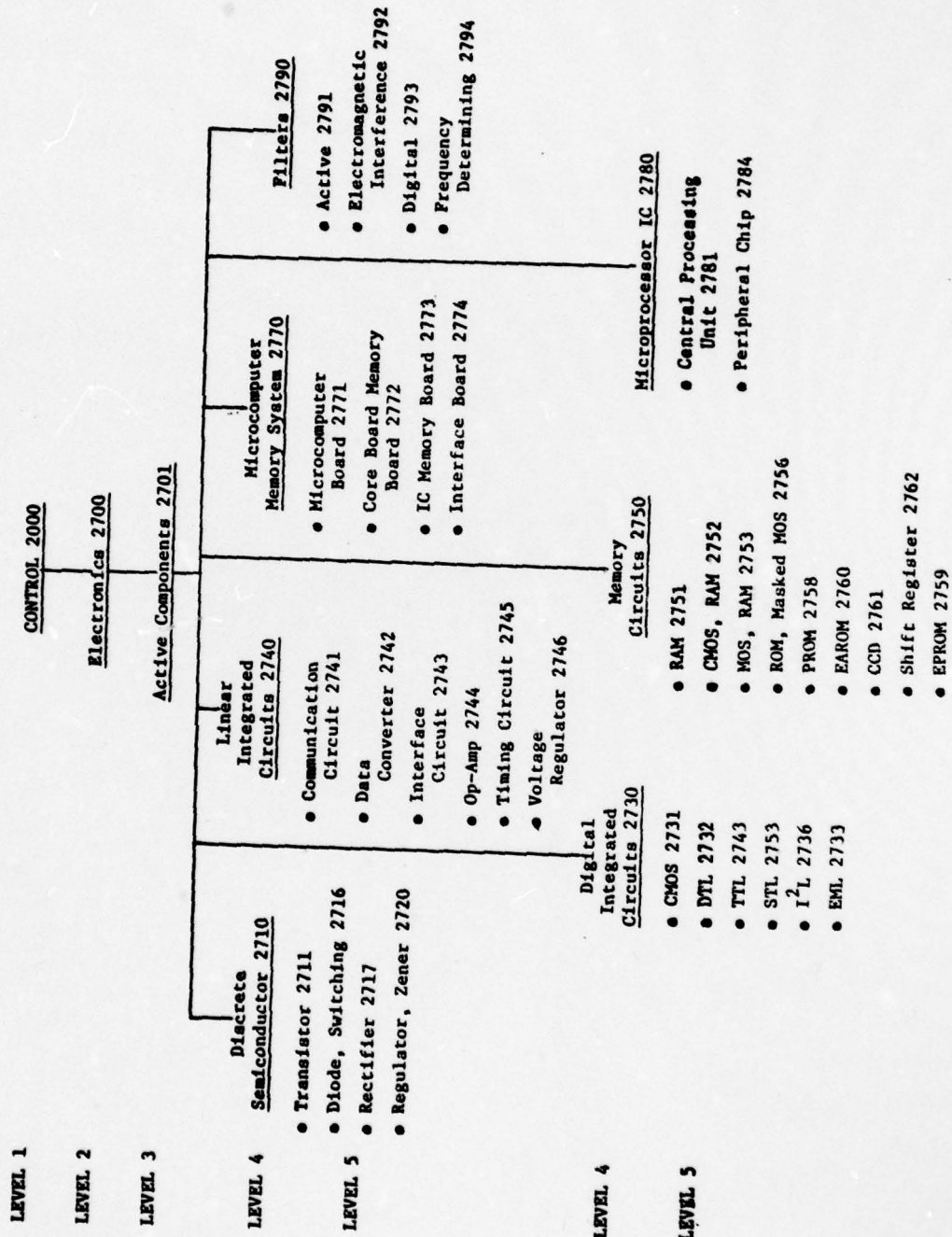


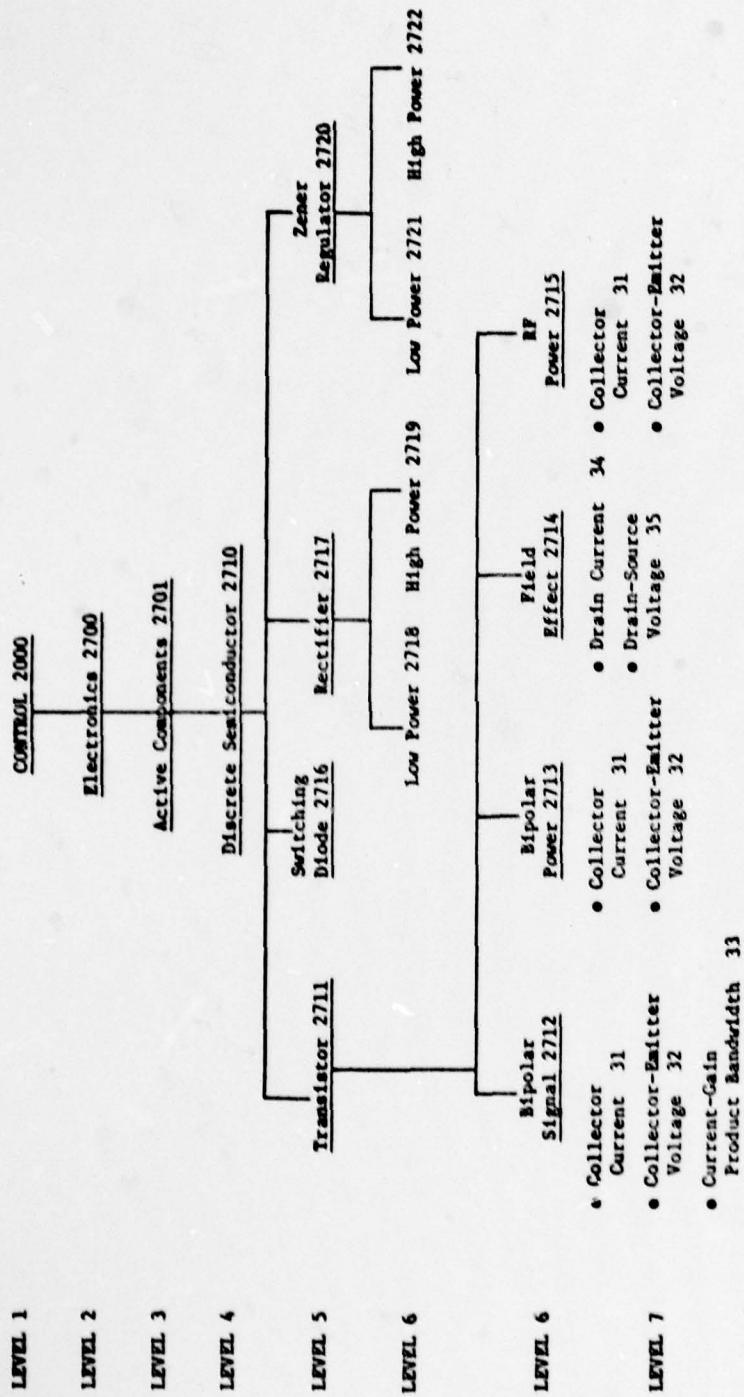


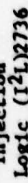


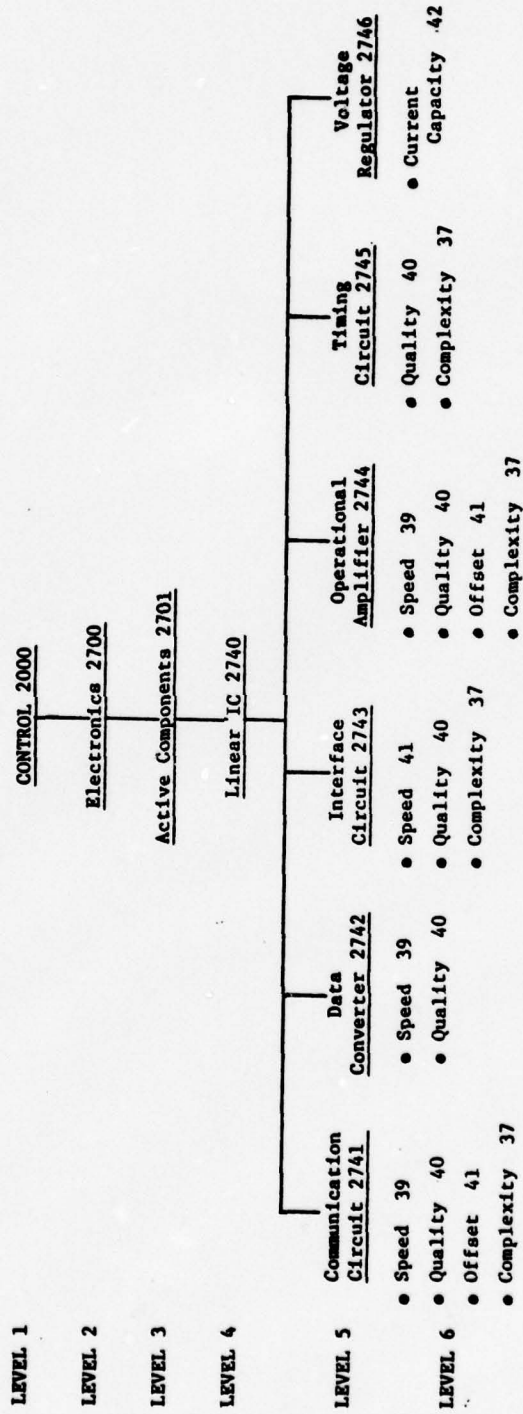


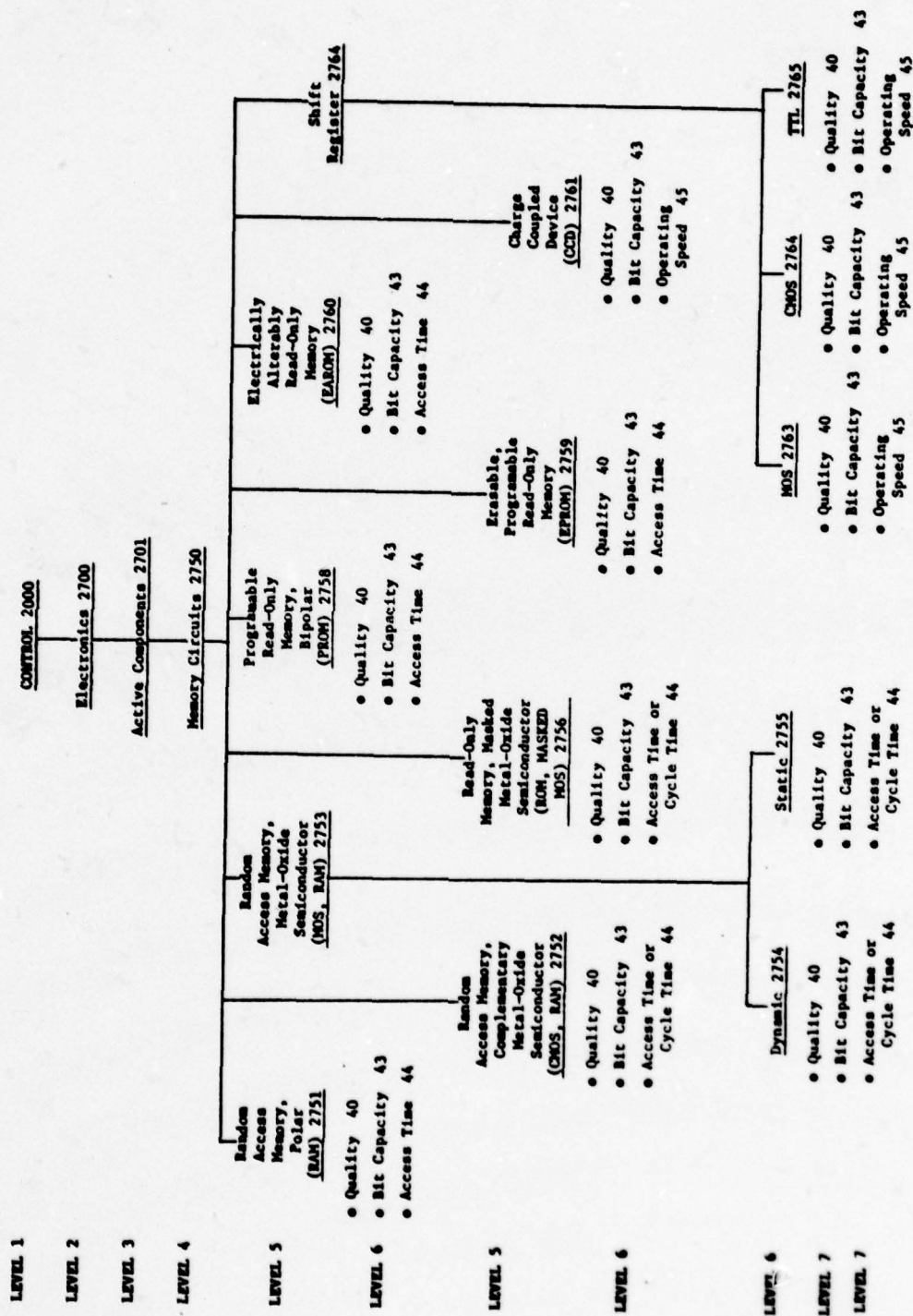


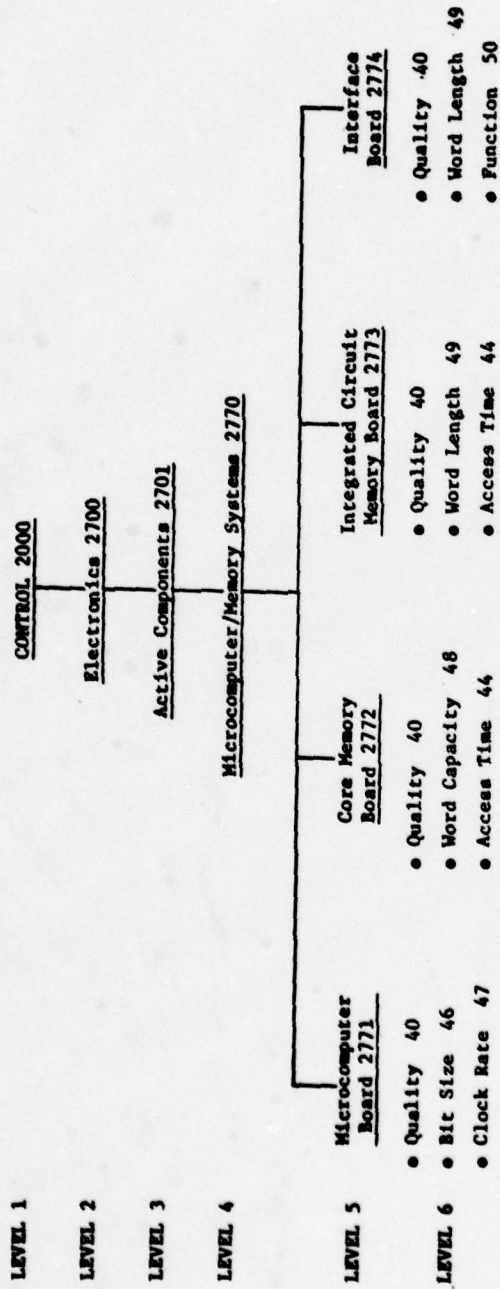


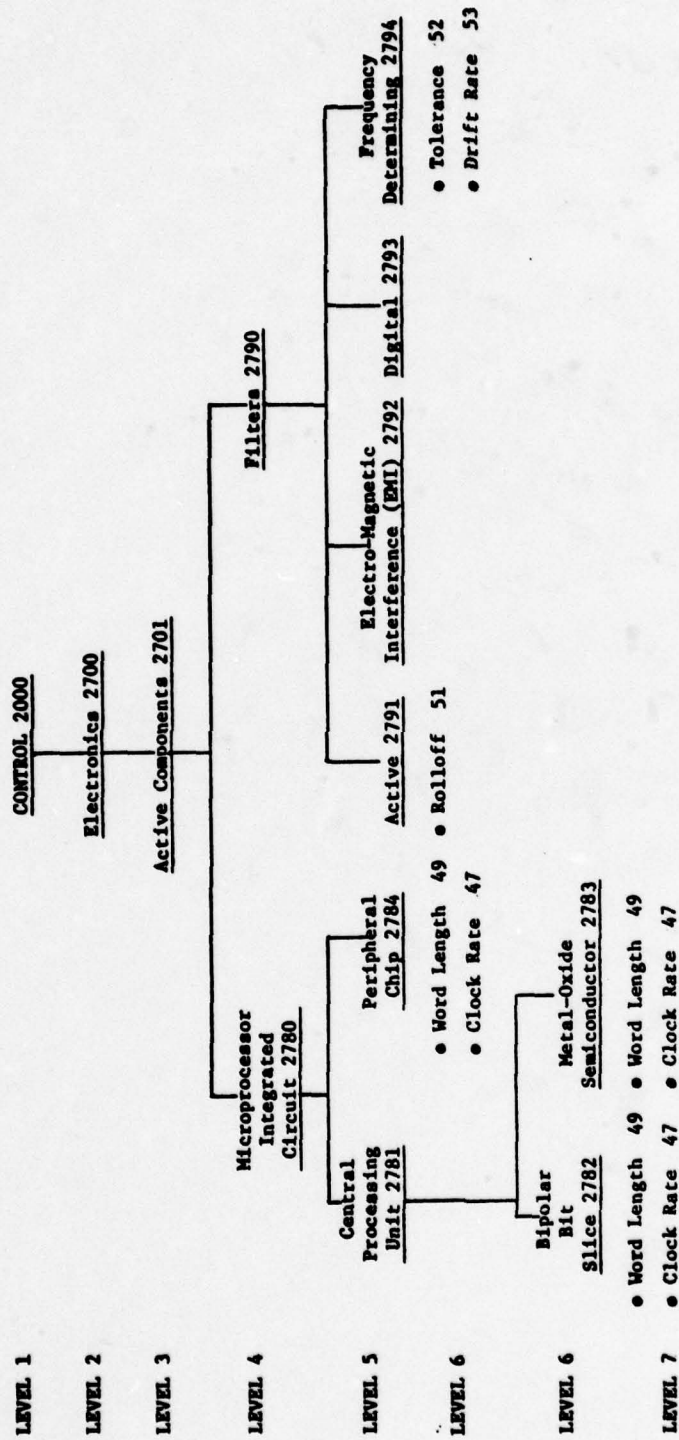


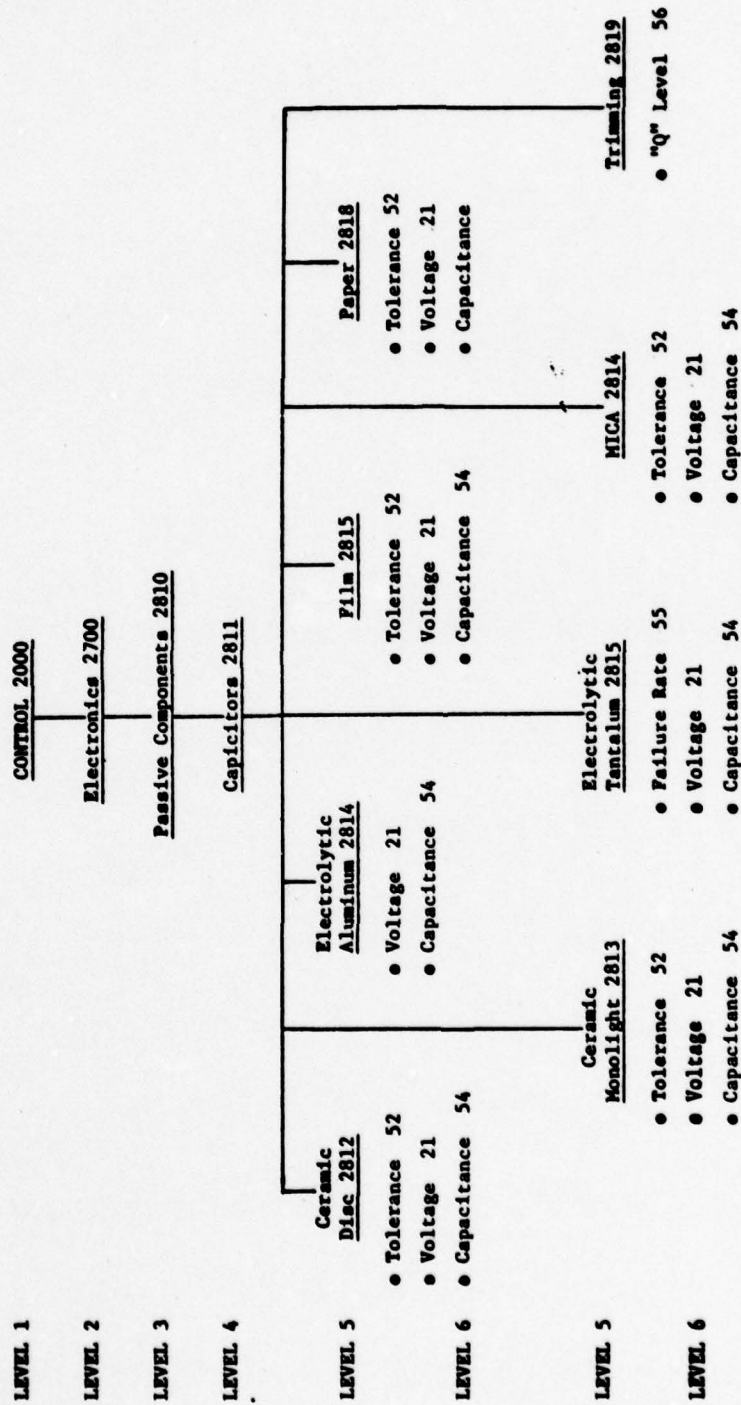


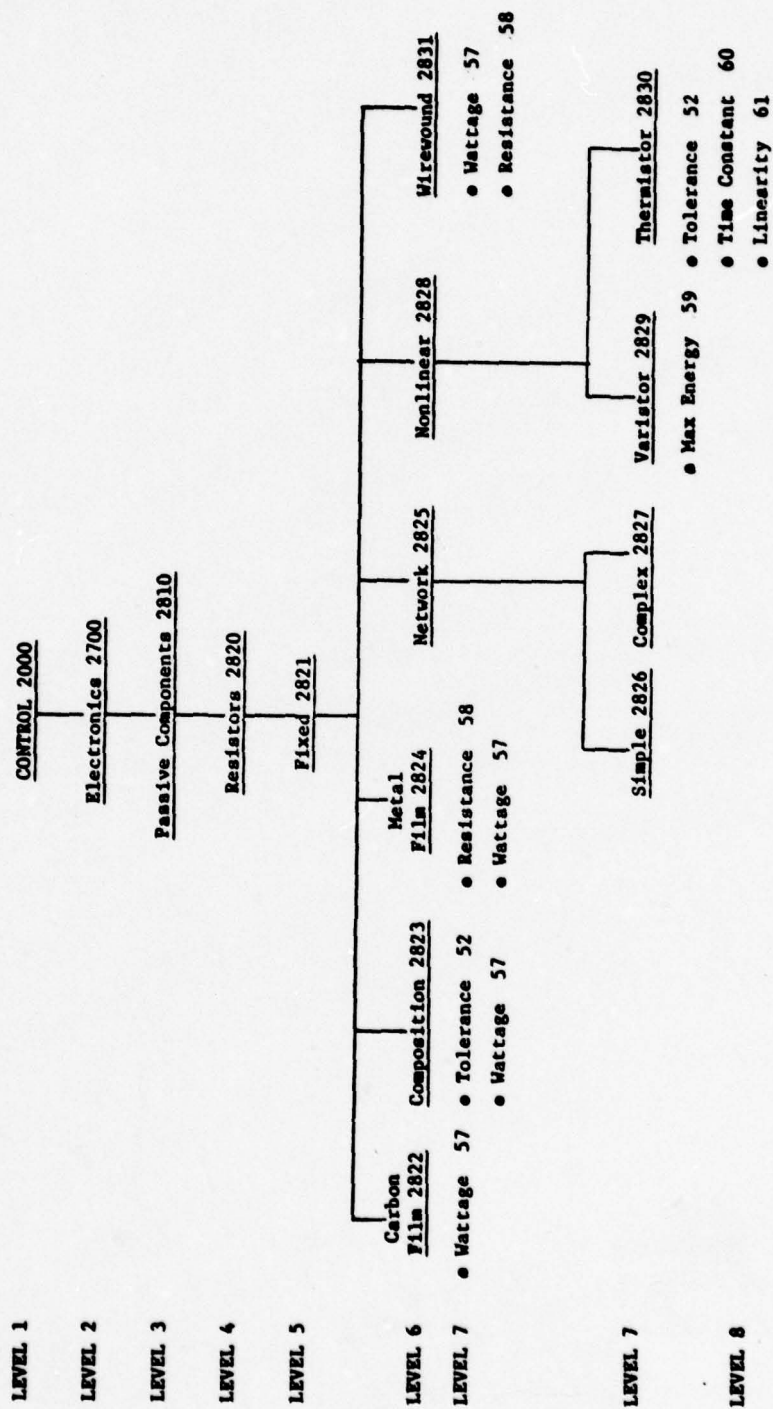


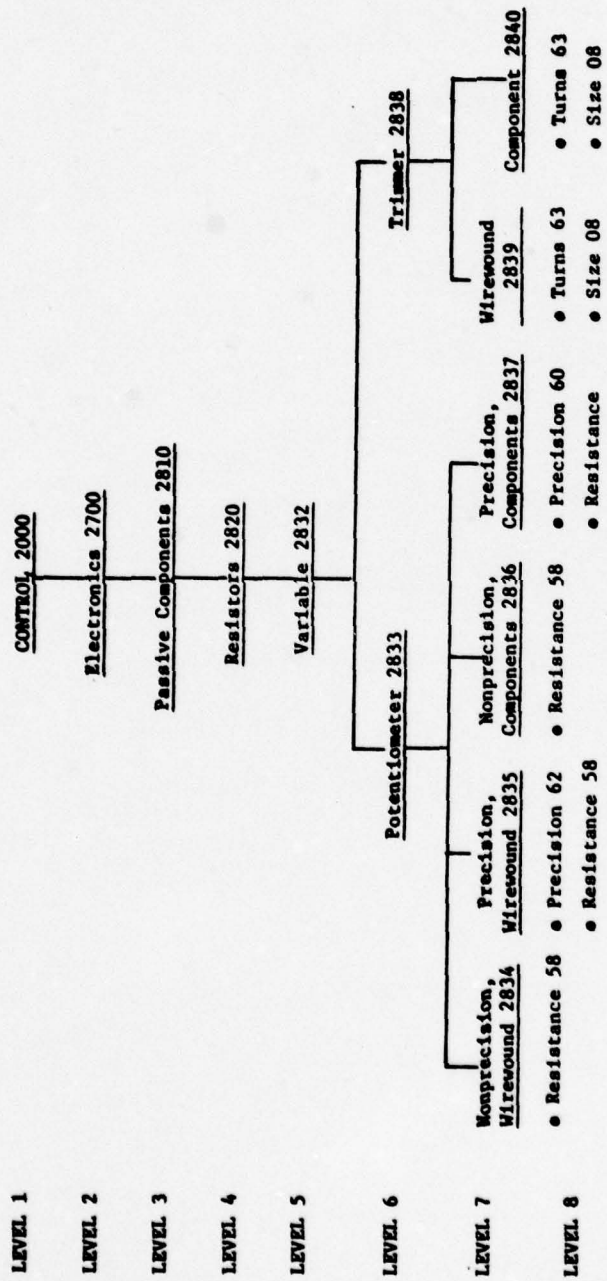


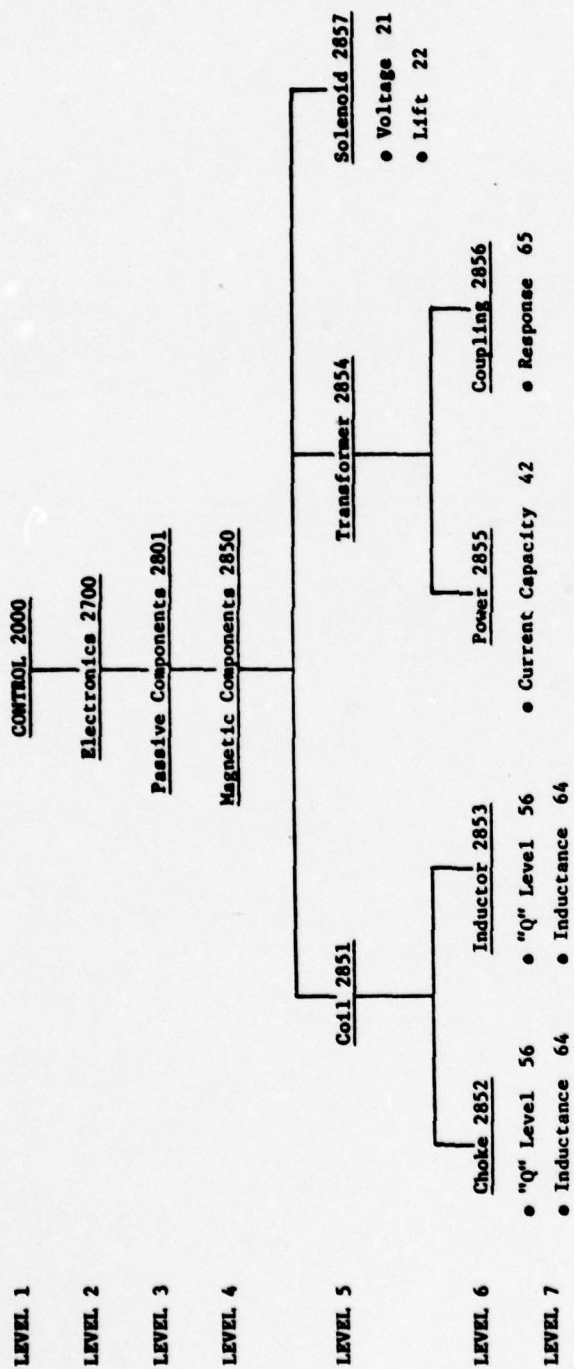


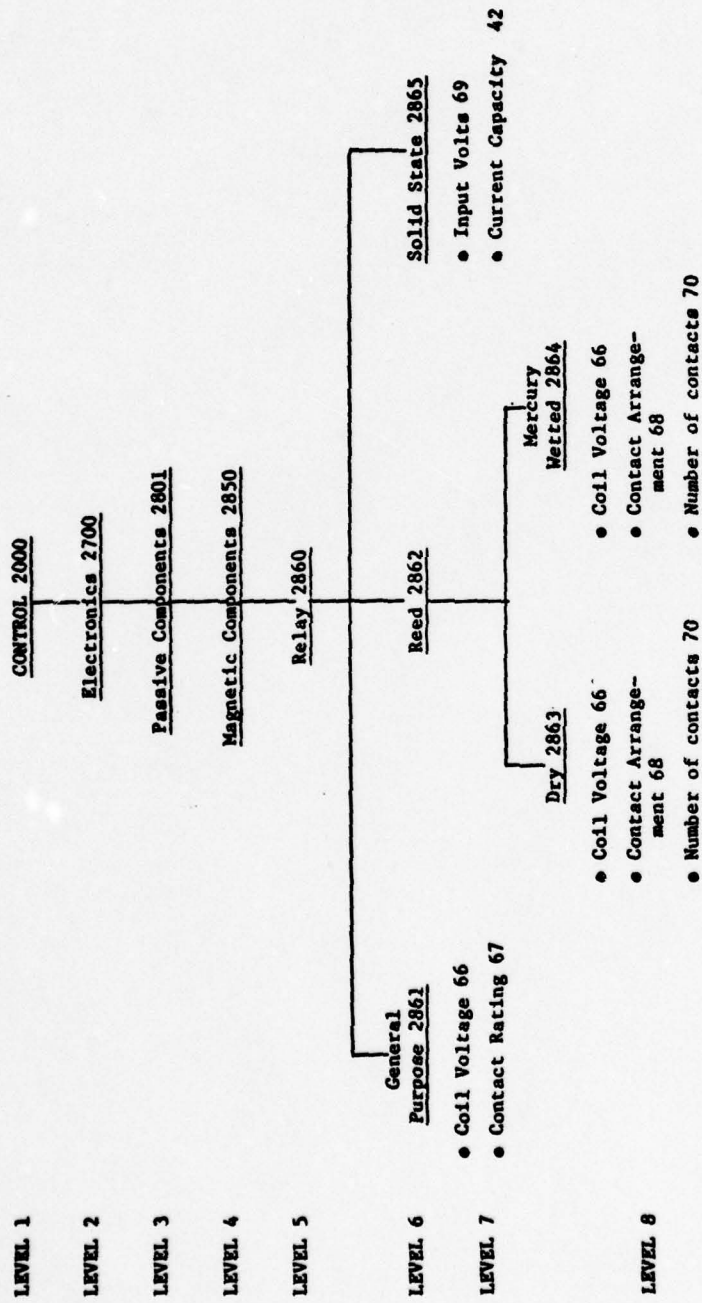


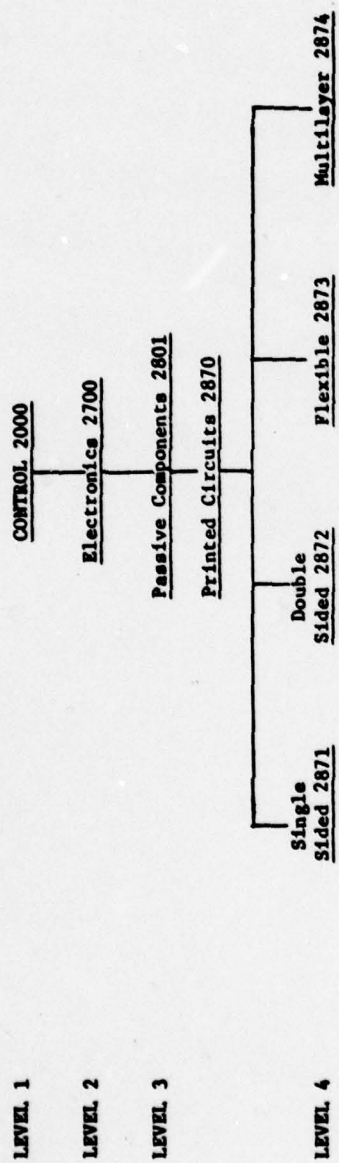


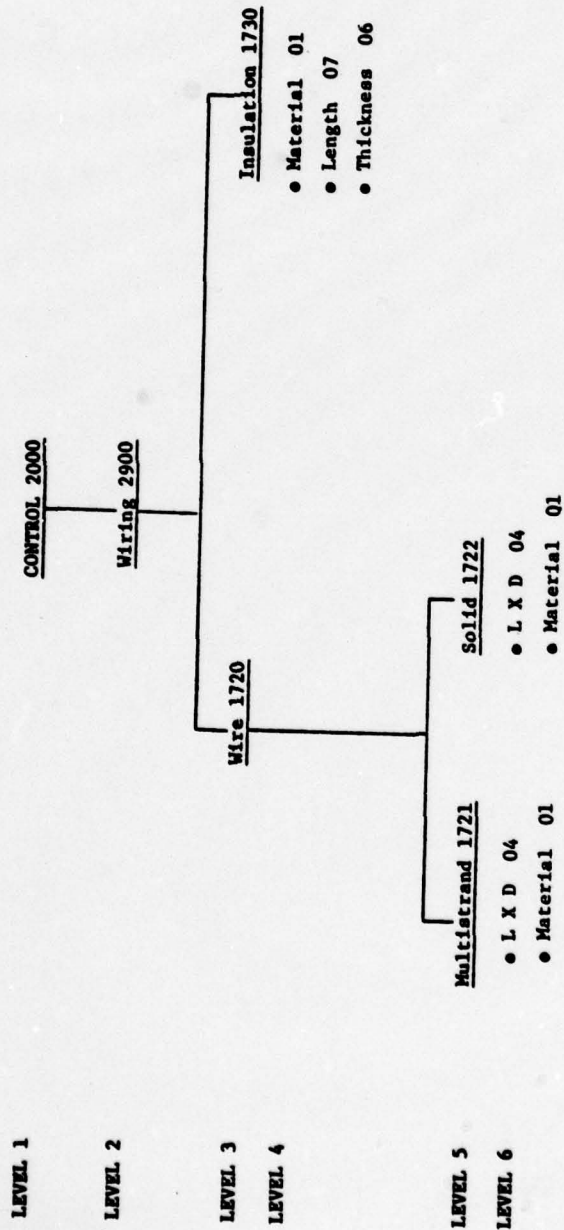


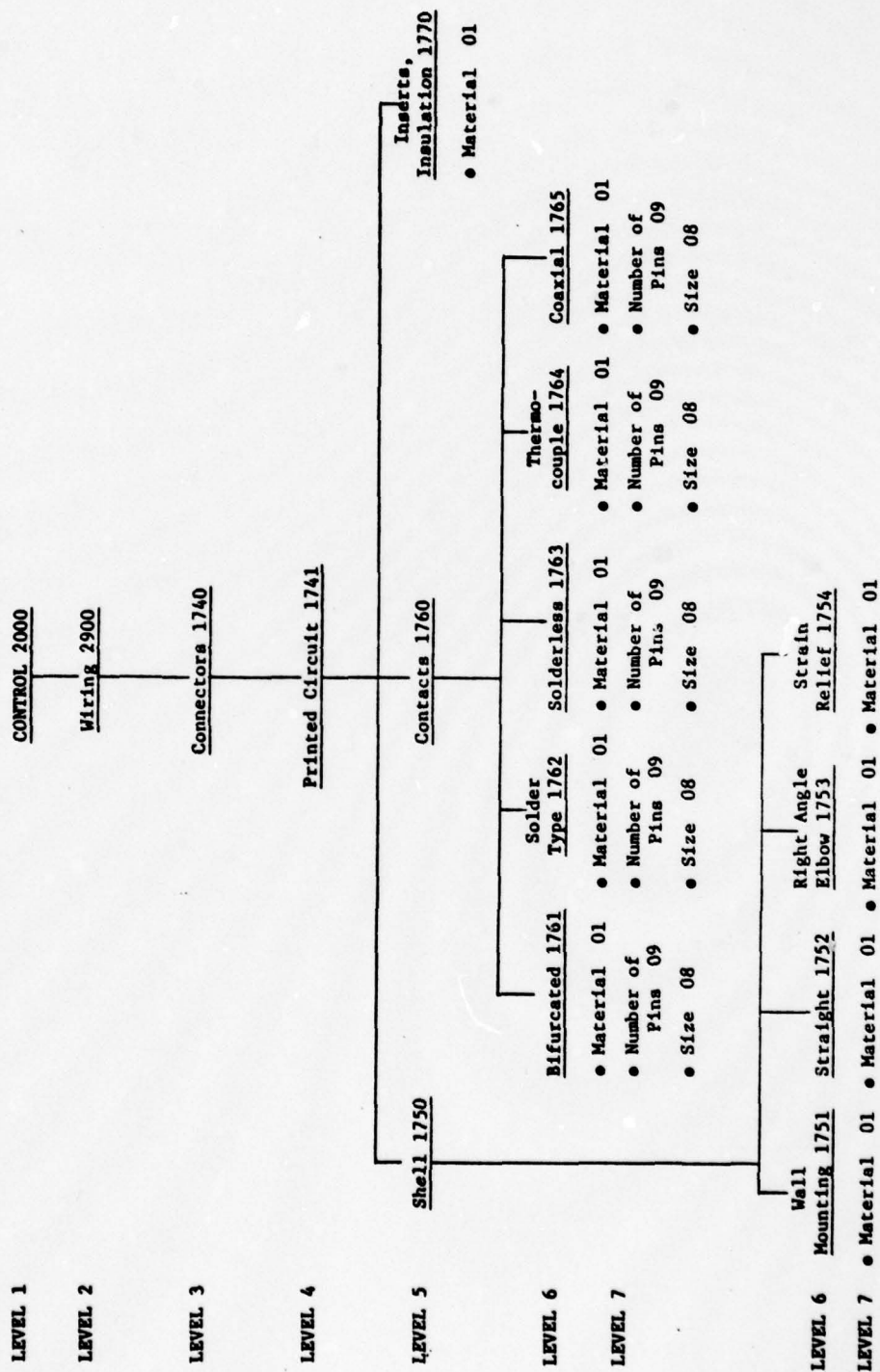


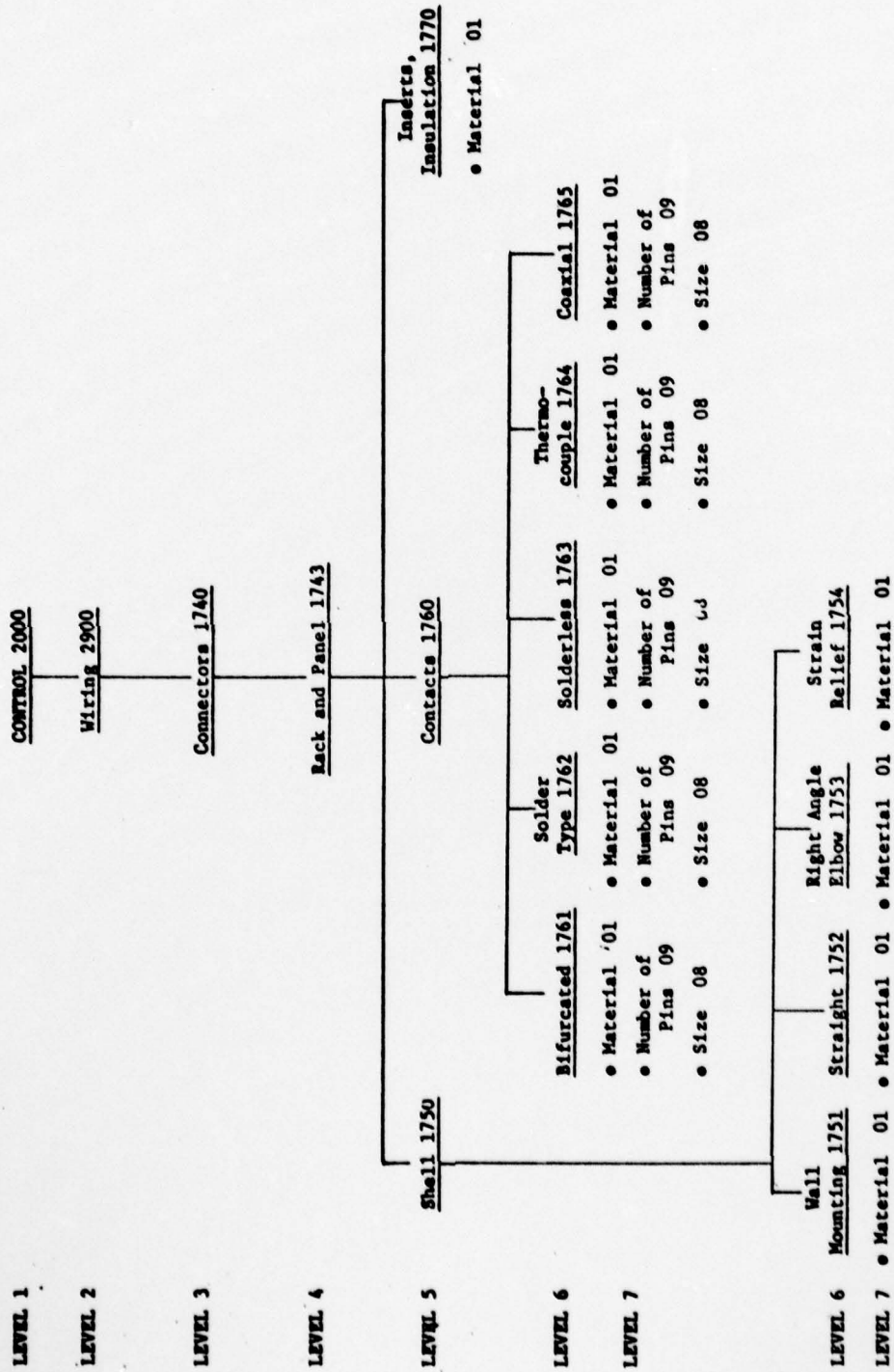


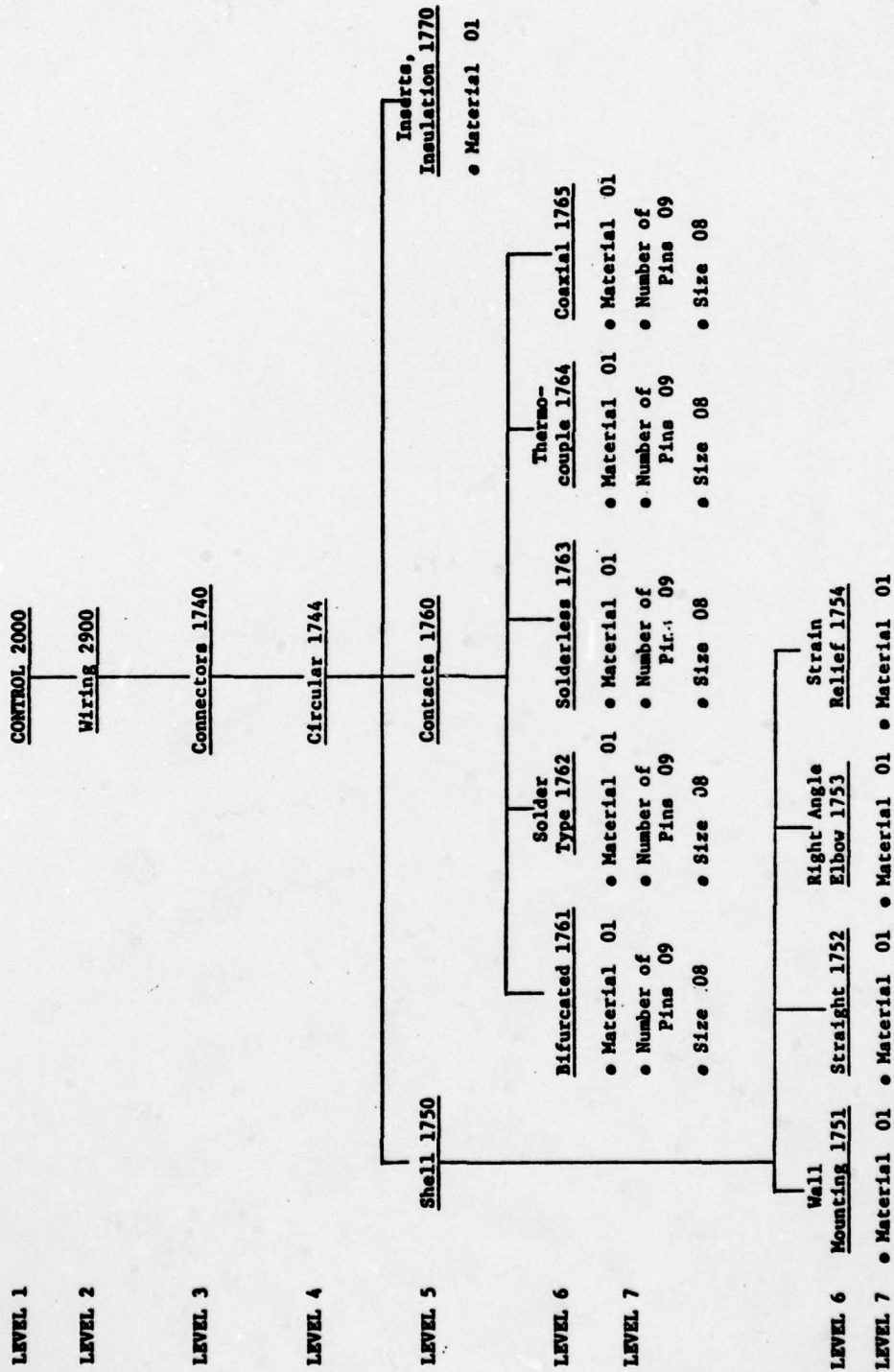


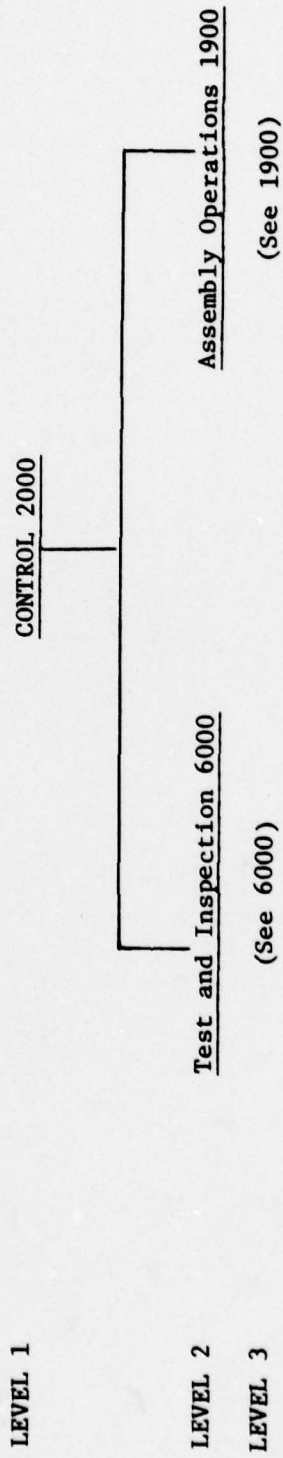


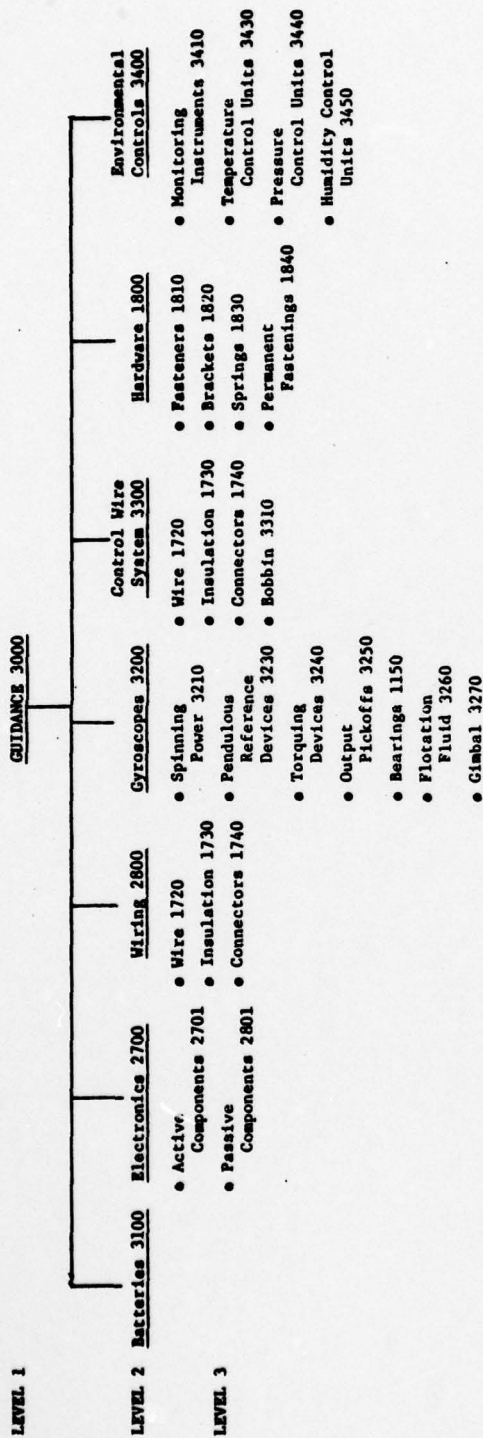


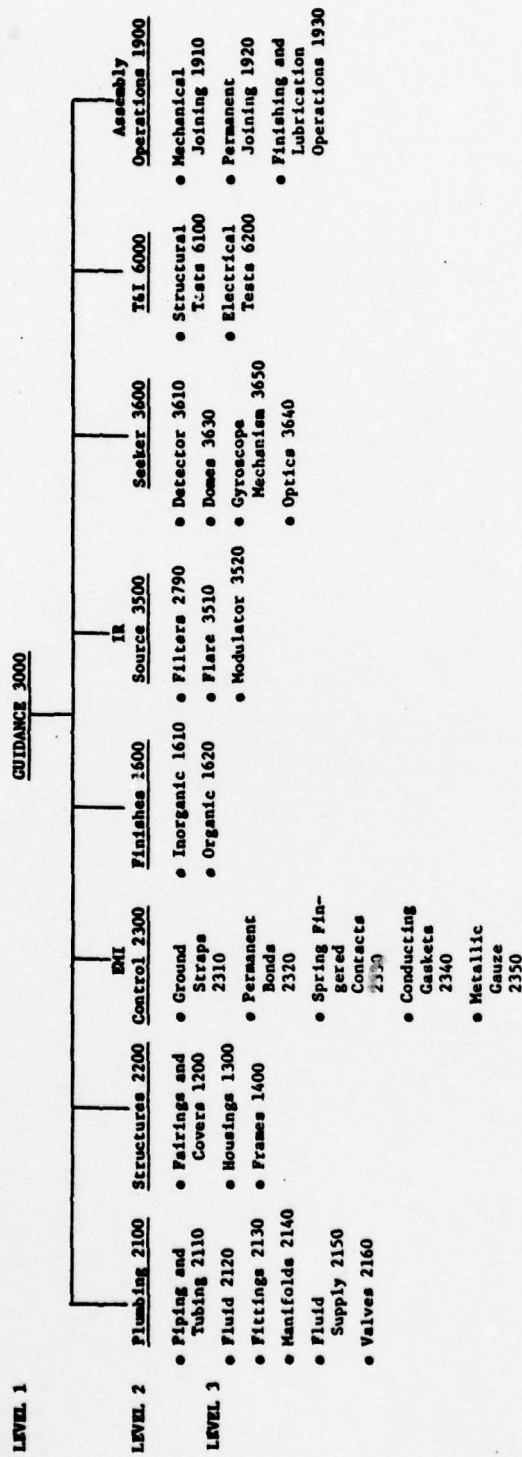


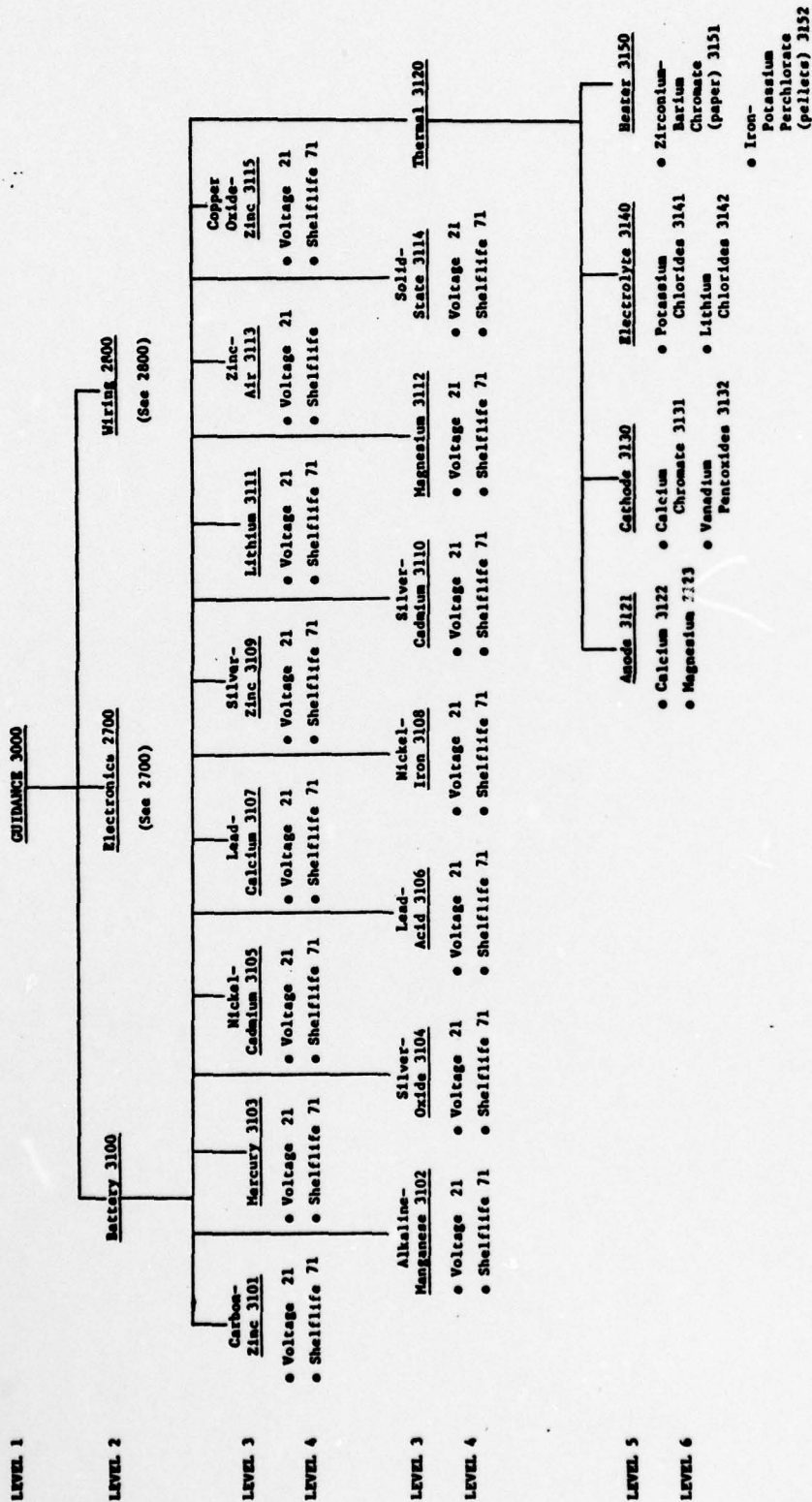


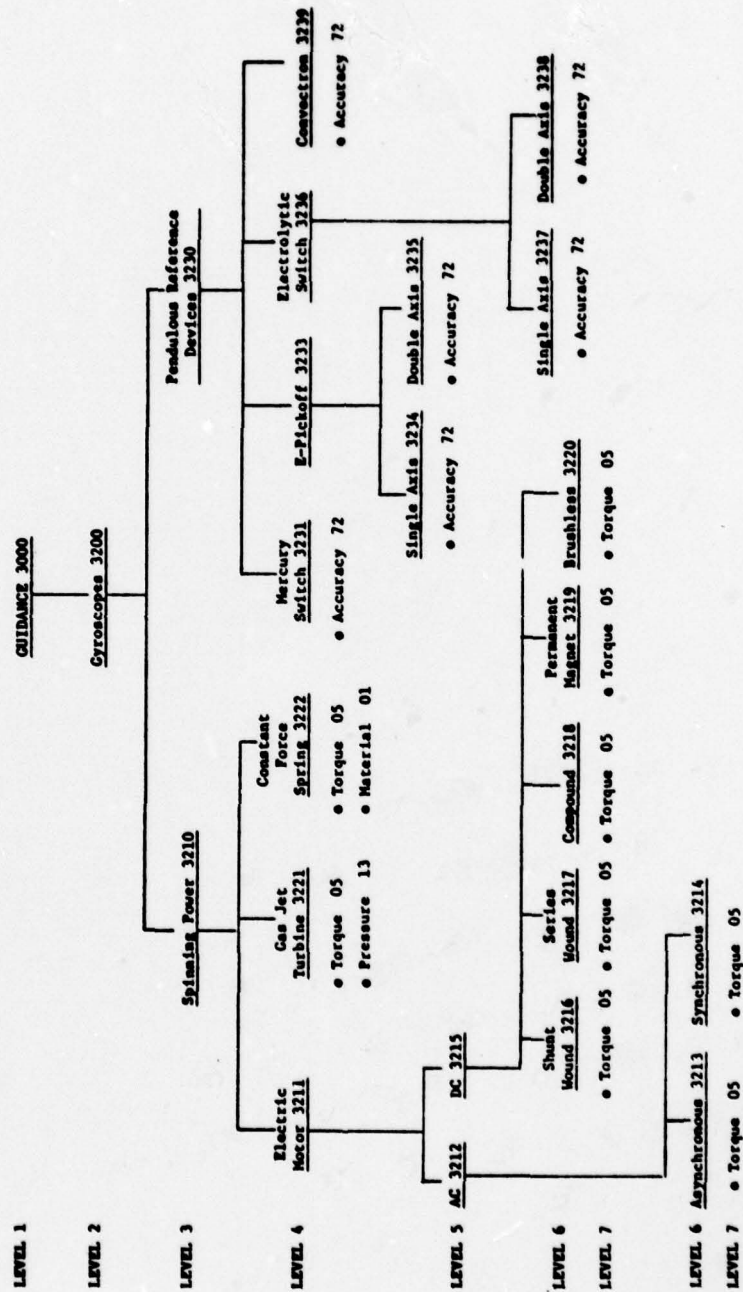


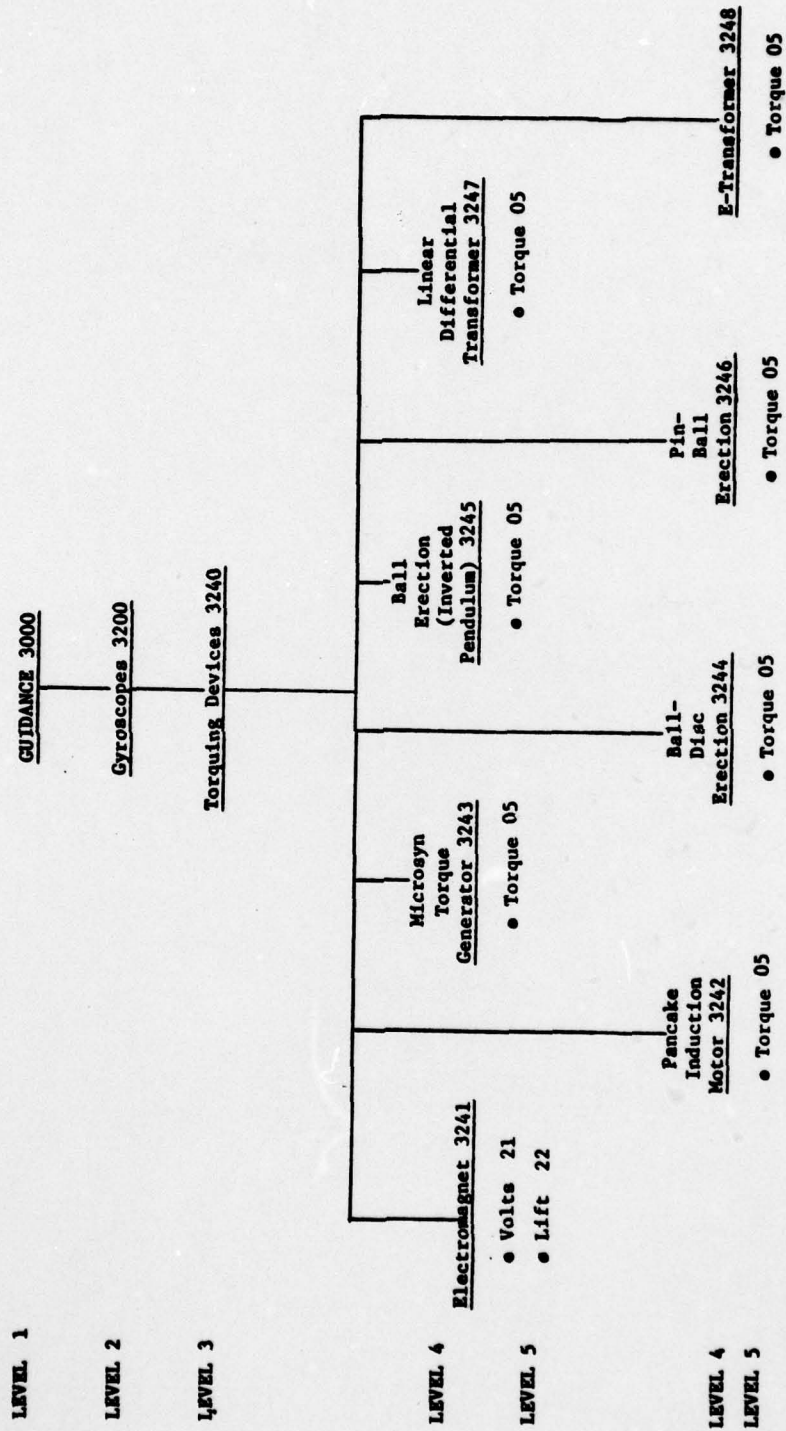


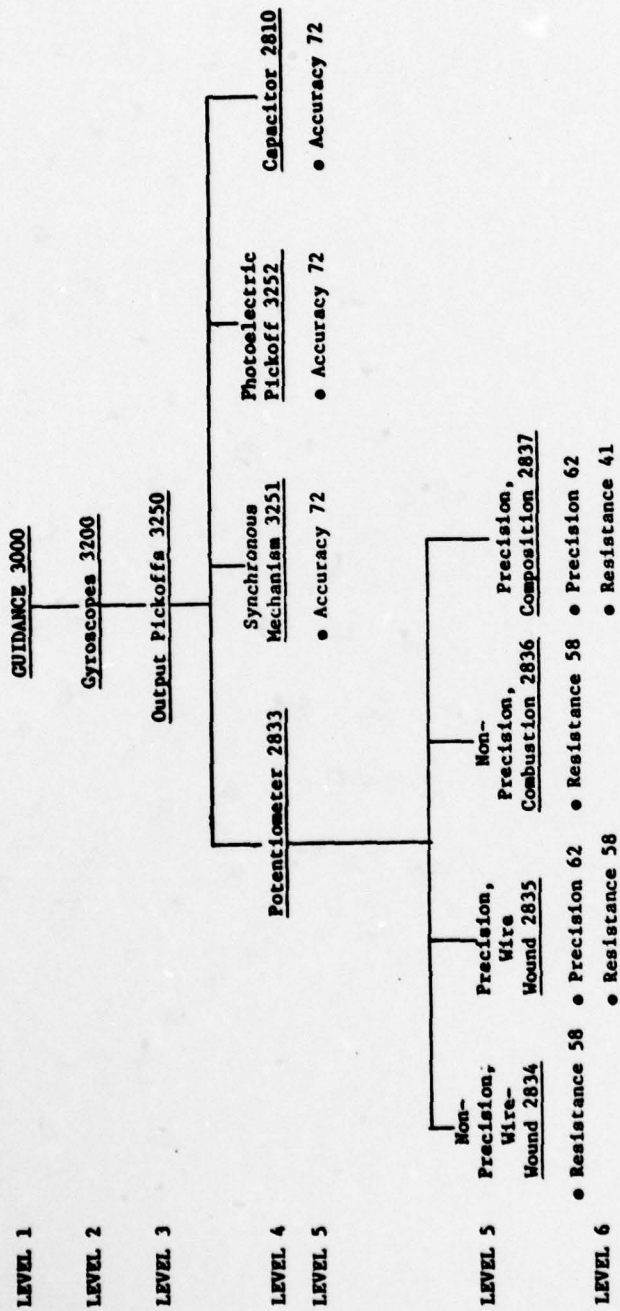


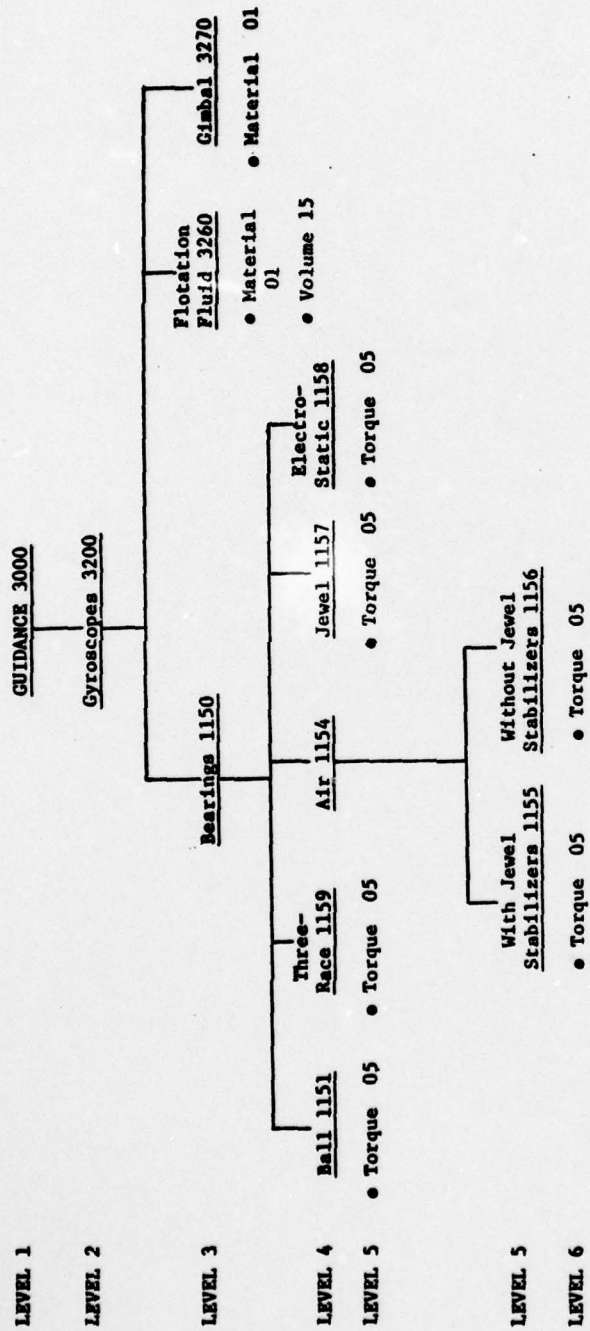


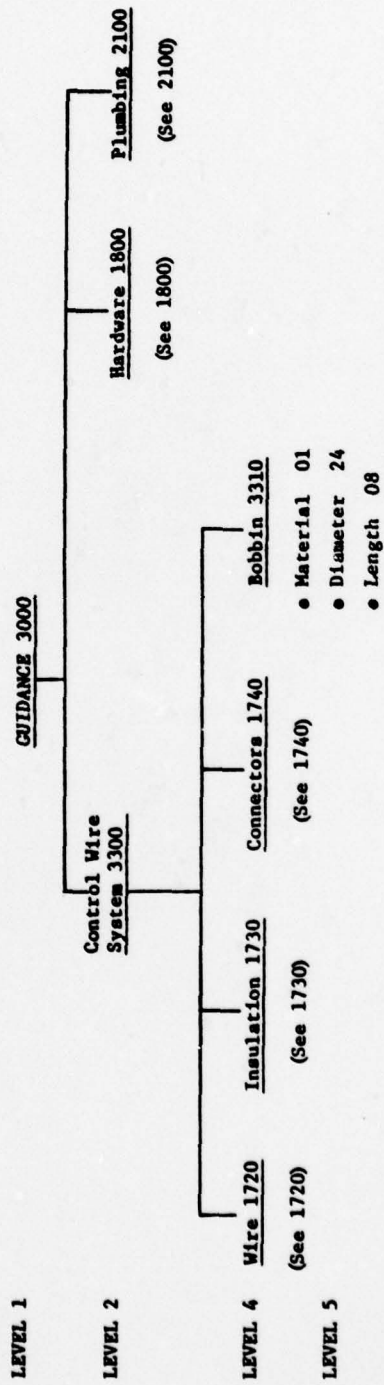


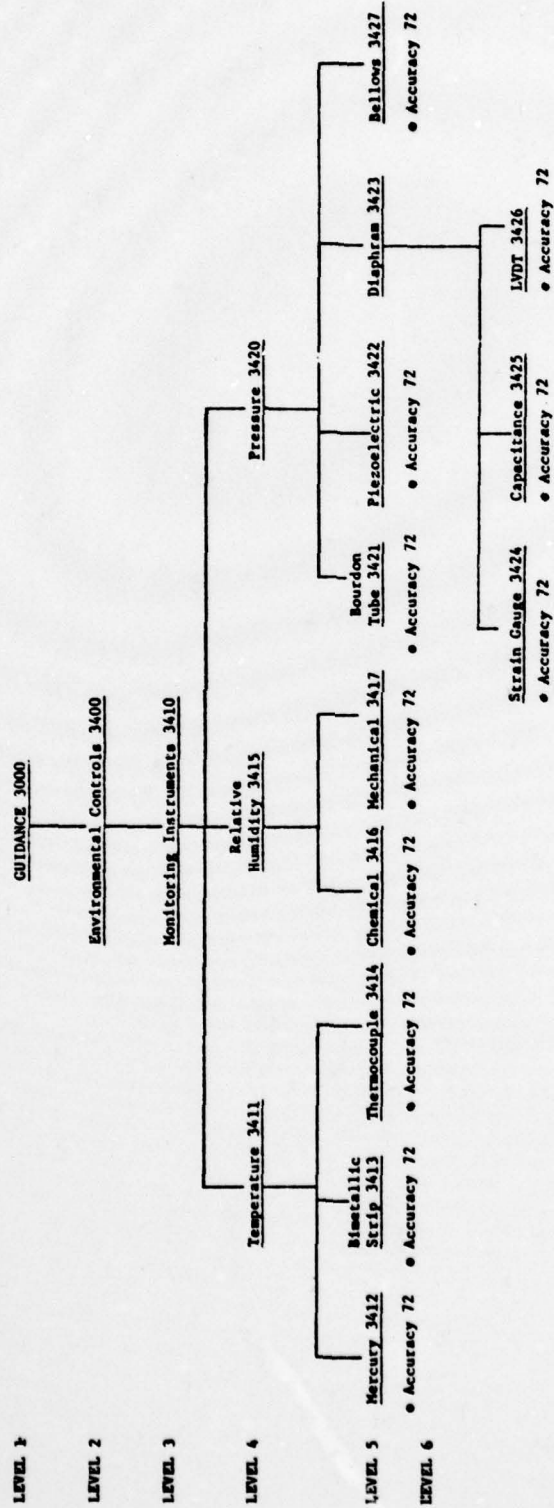


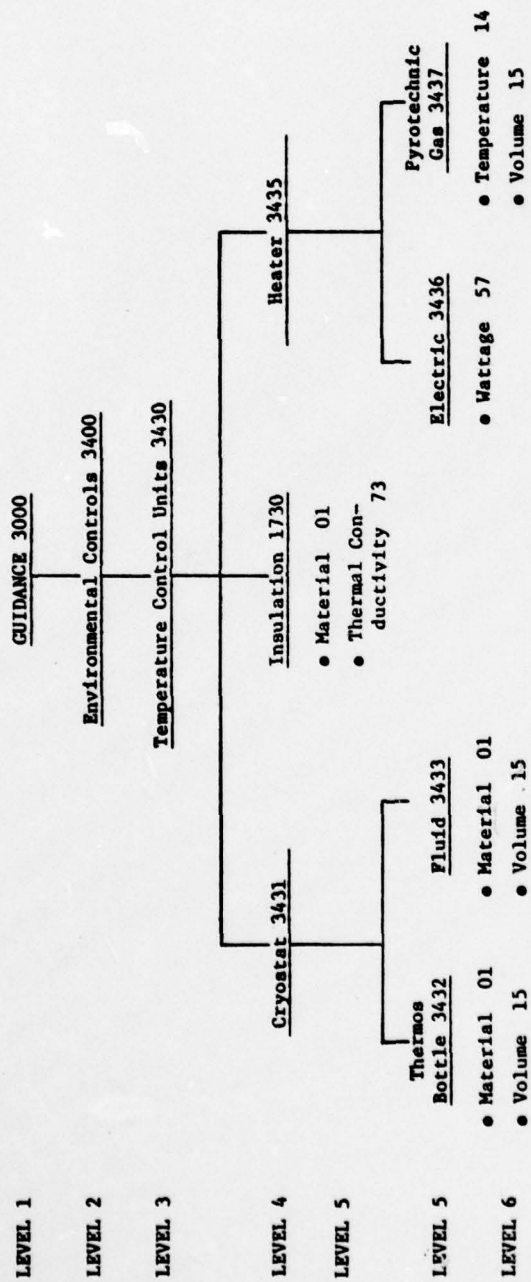












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BATTELLE COLUMBUS LABS OH
COST-DRIVER ANALYSIS FOR COMPUTERIZED PRODUCTION PROCESS PLANNING-ETC(U)
JUL 79 T E HILL, T G BYRER, B R NOTON

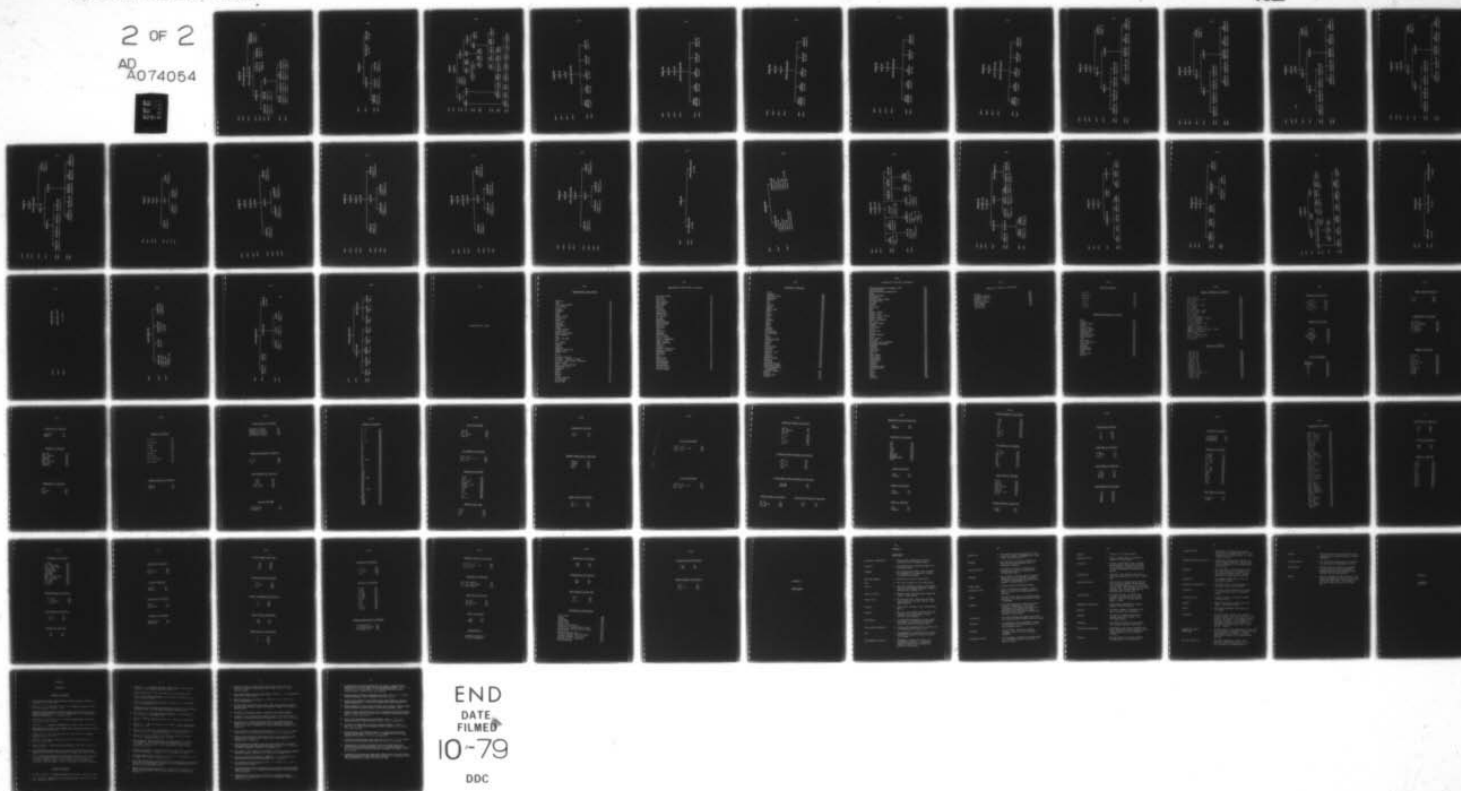
F/G 15/7
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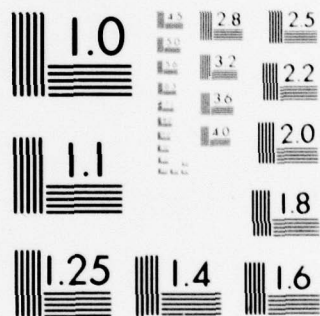
UNCLASSIFIED

NL

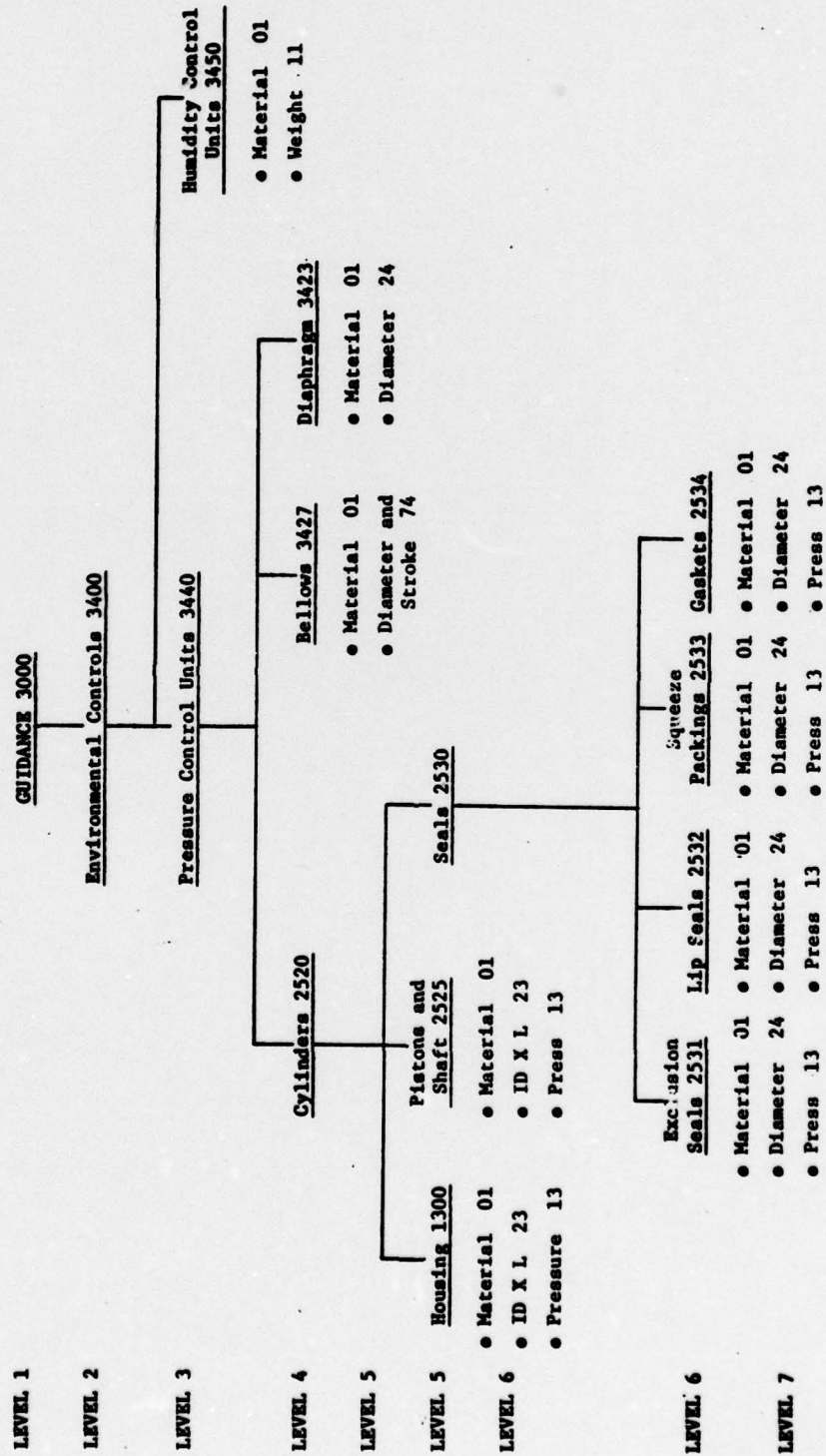
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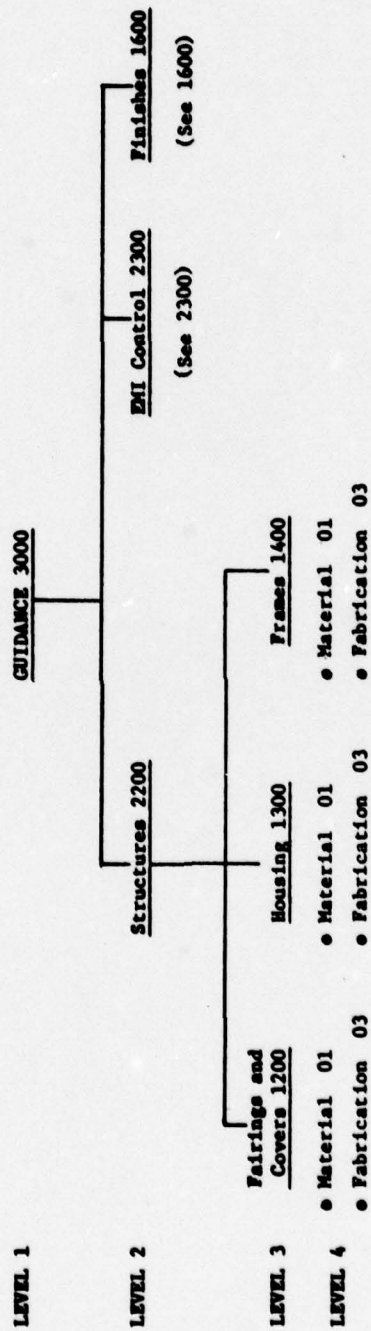
AD
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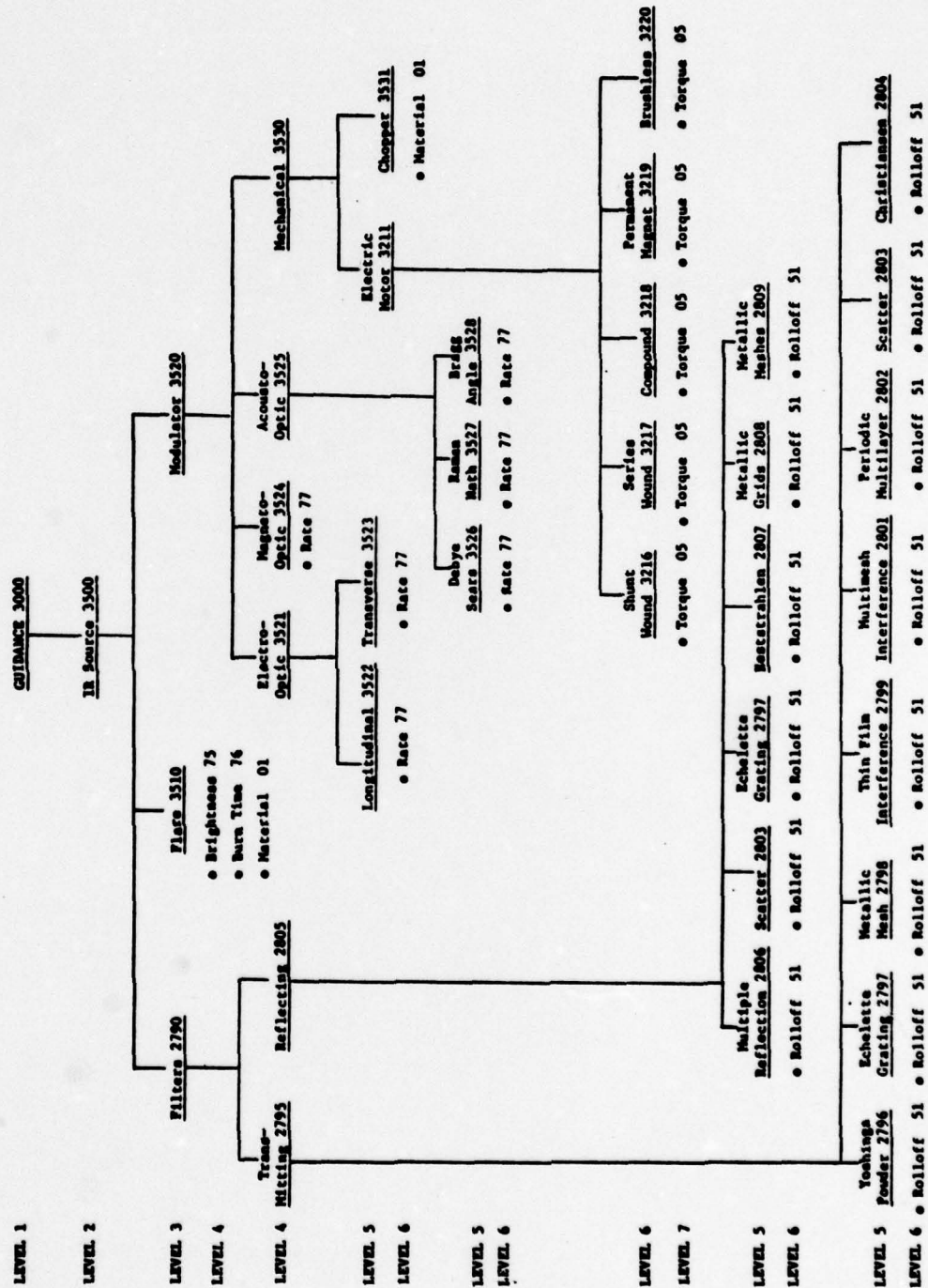


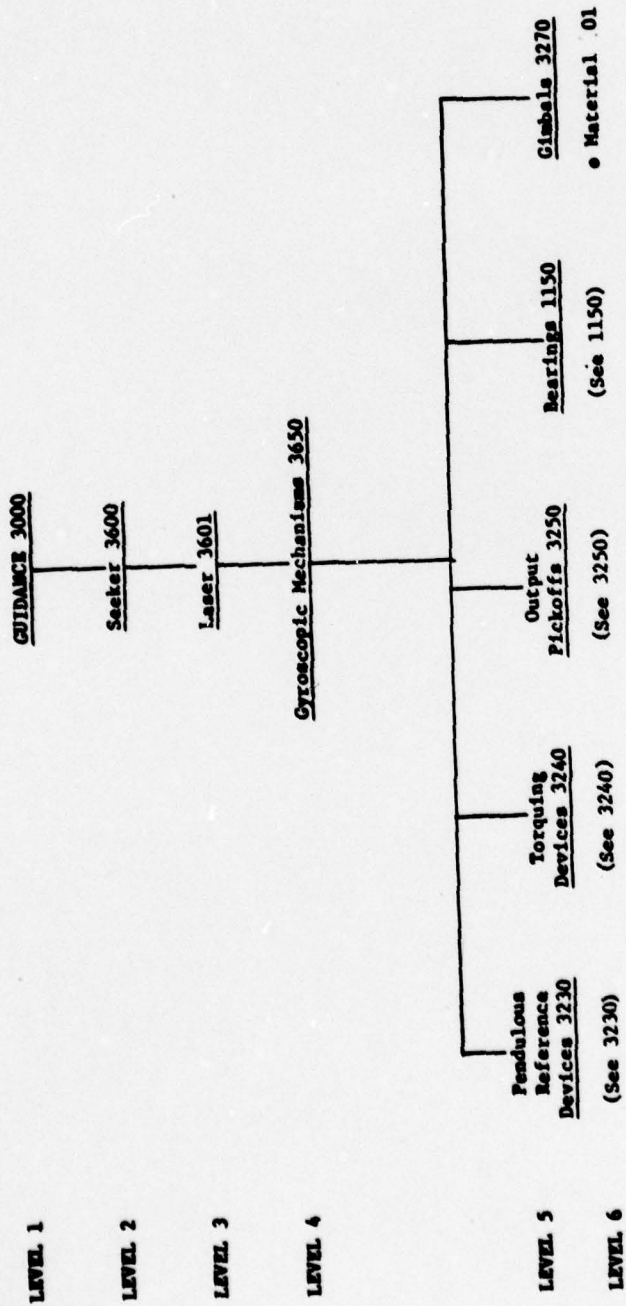


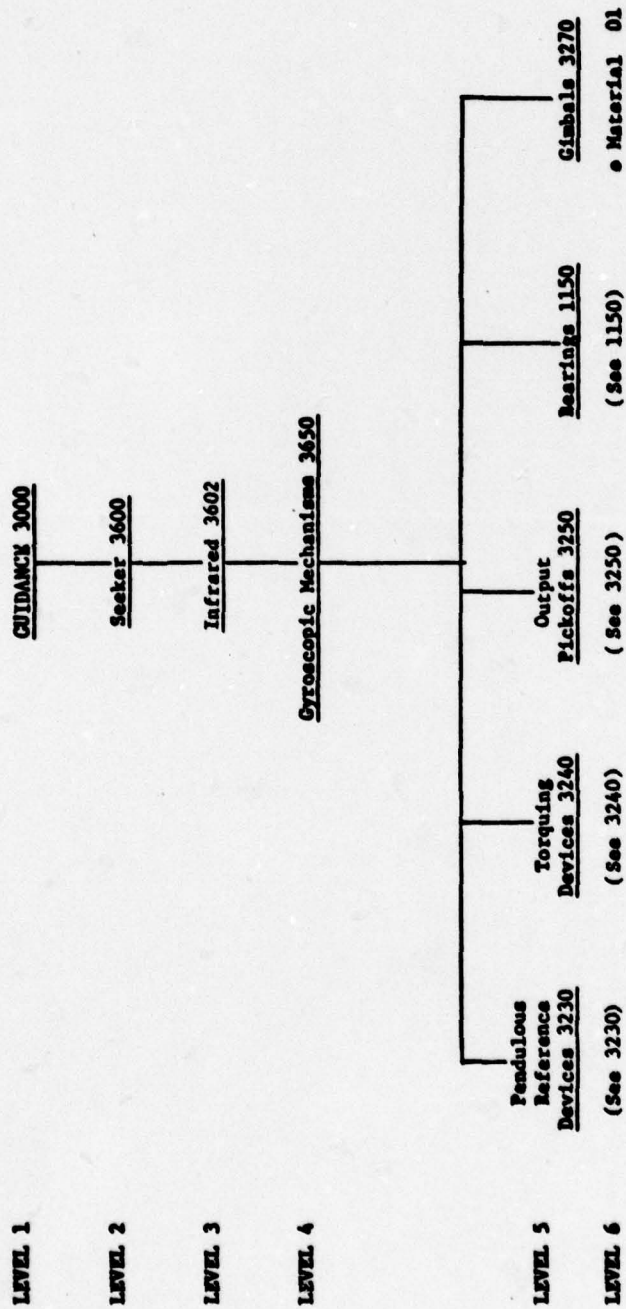
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

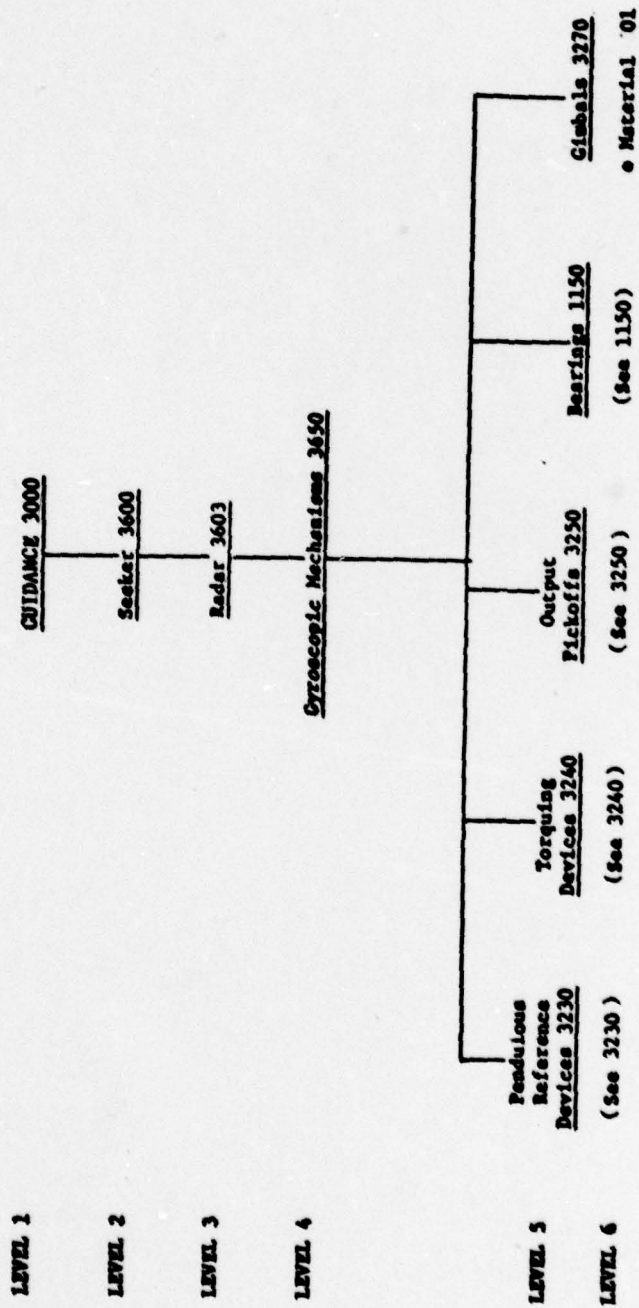


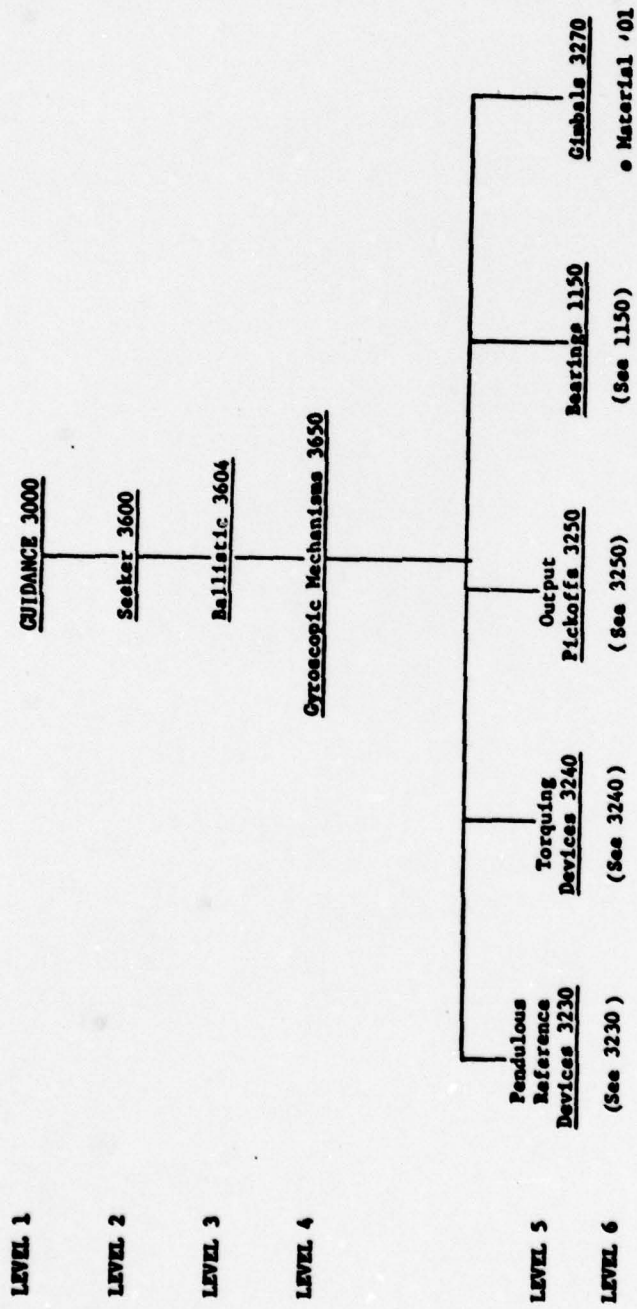


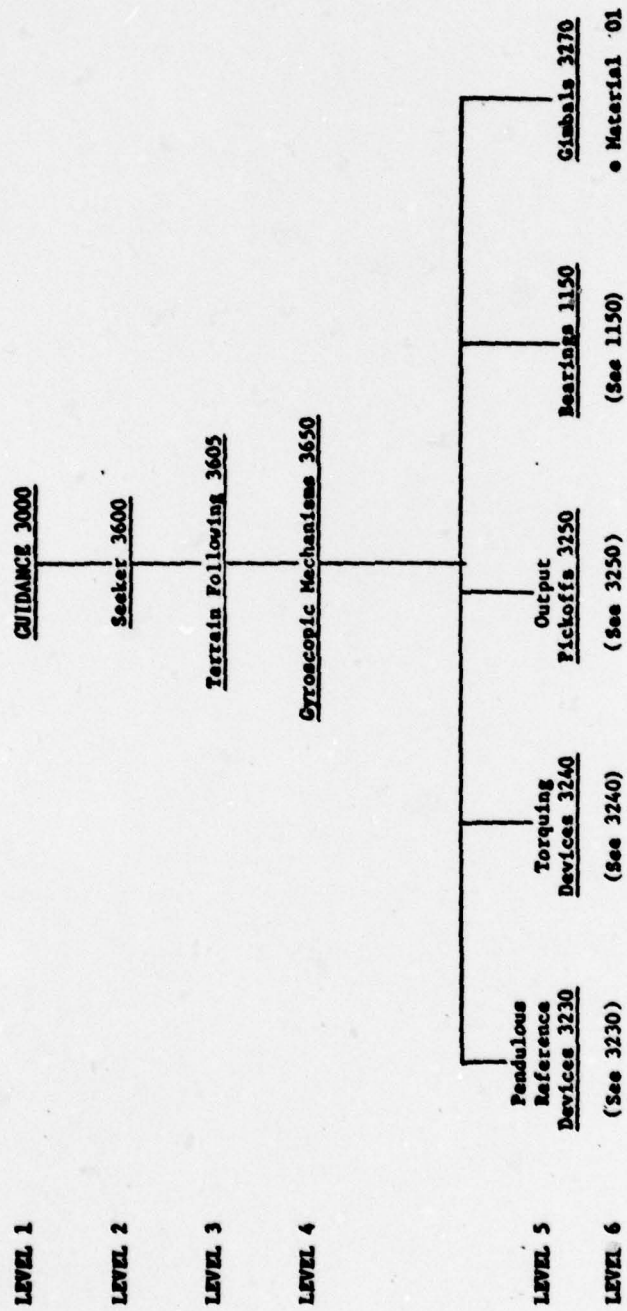


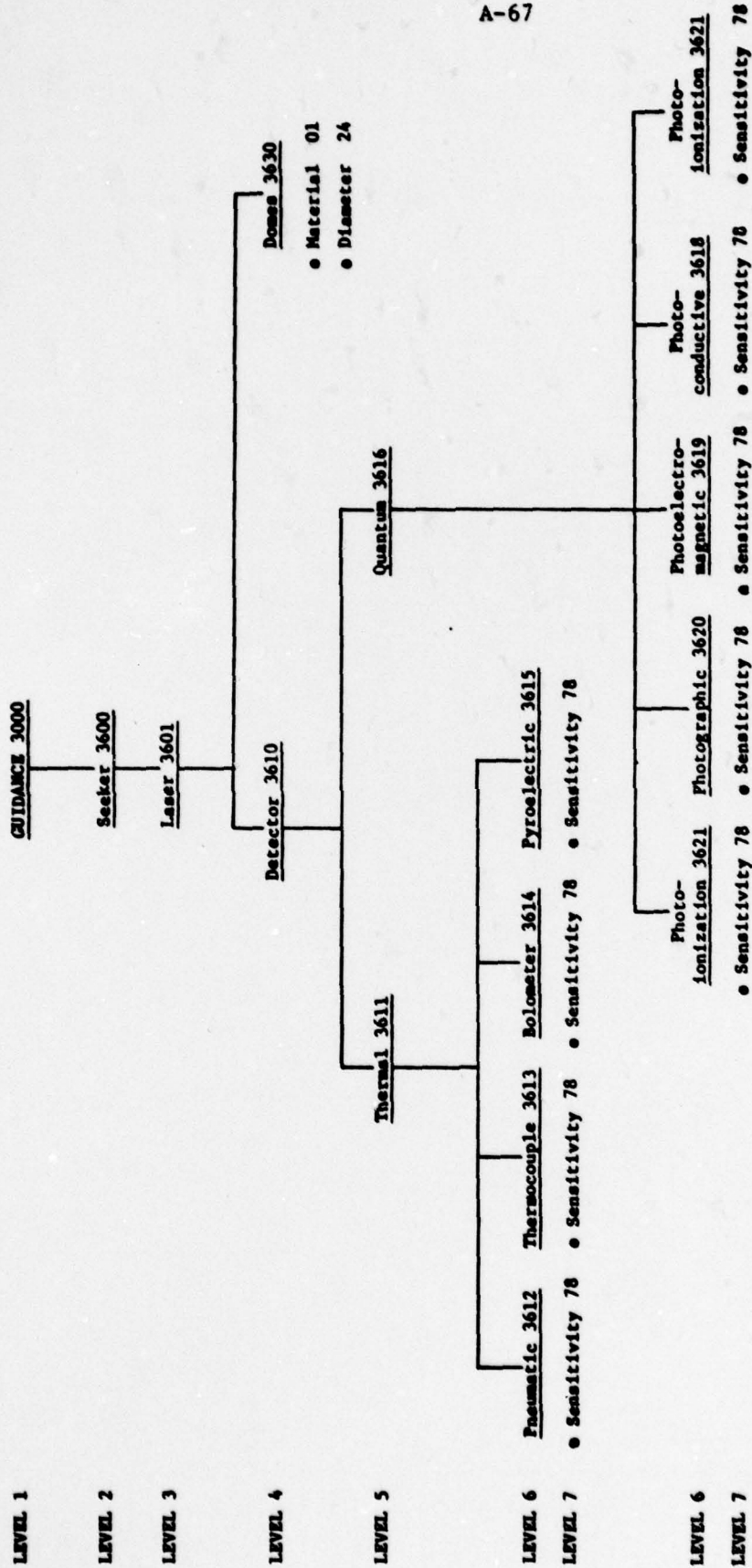


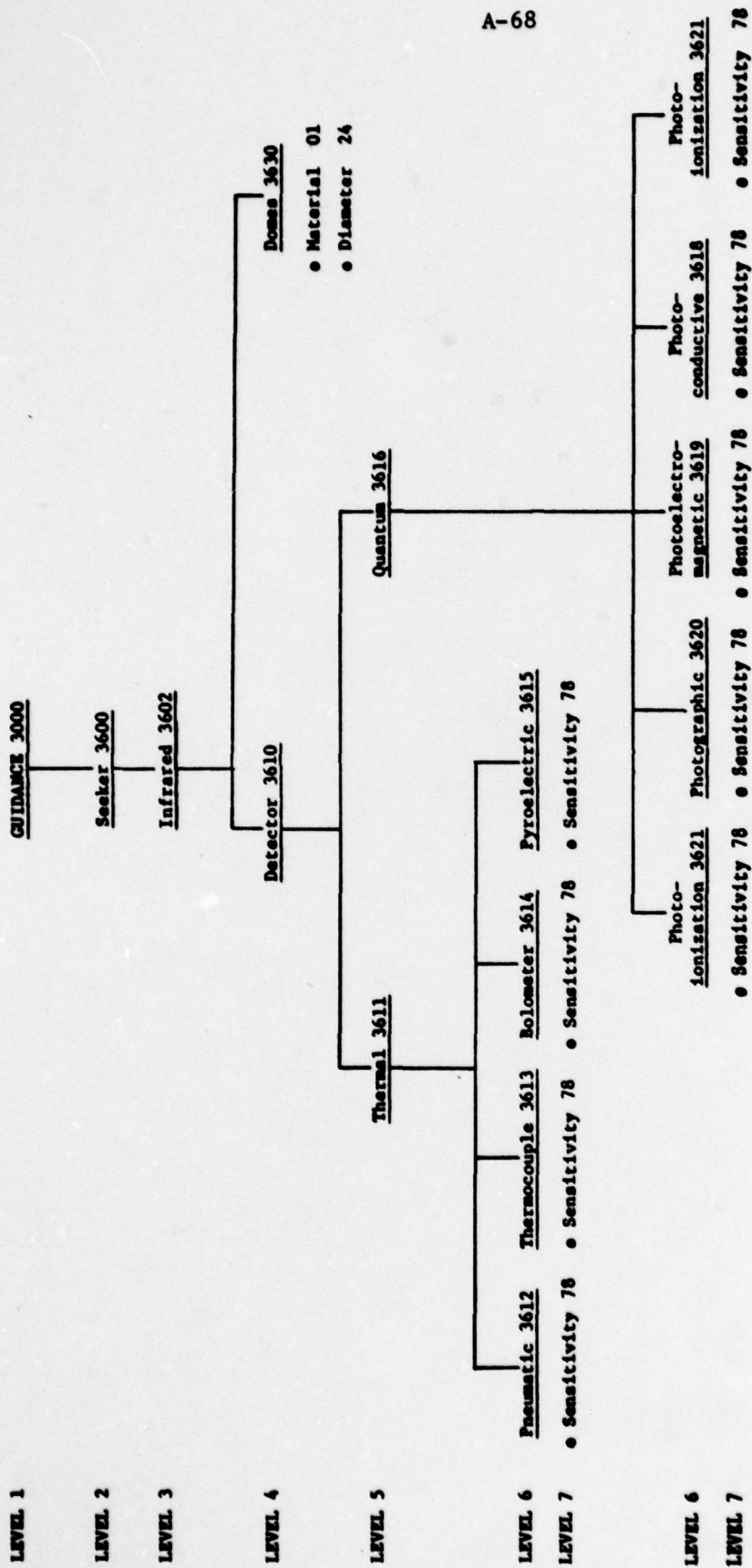


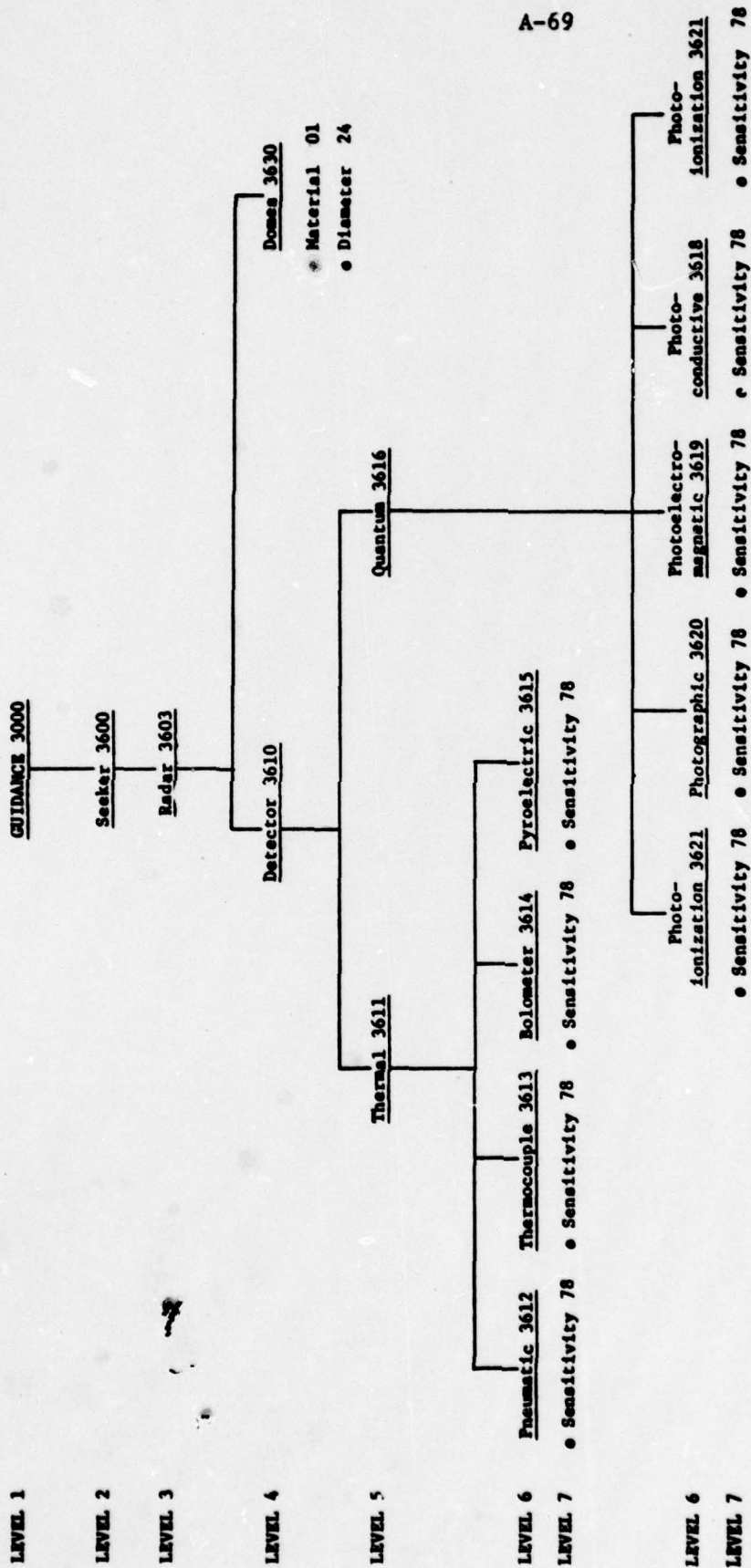


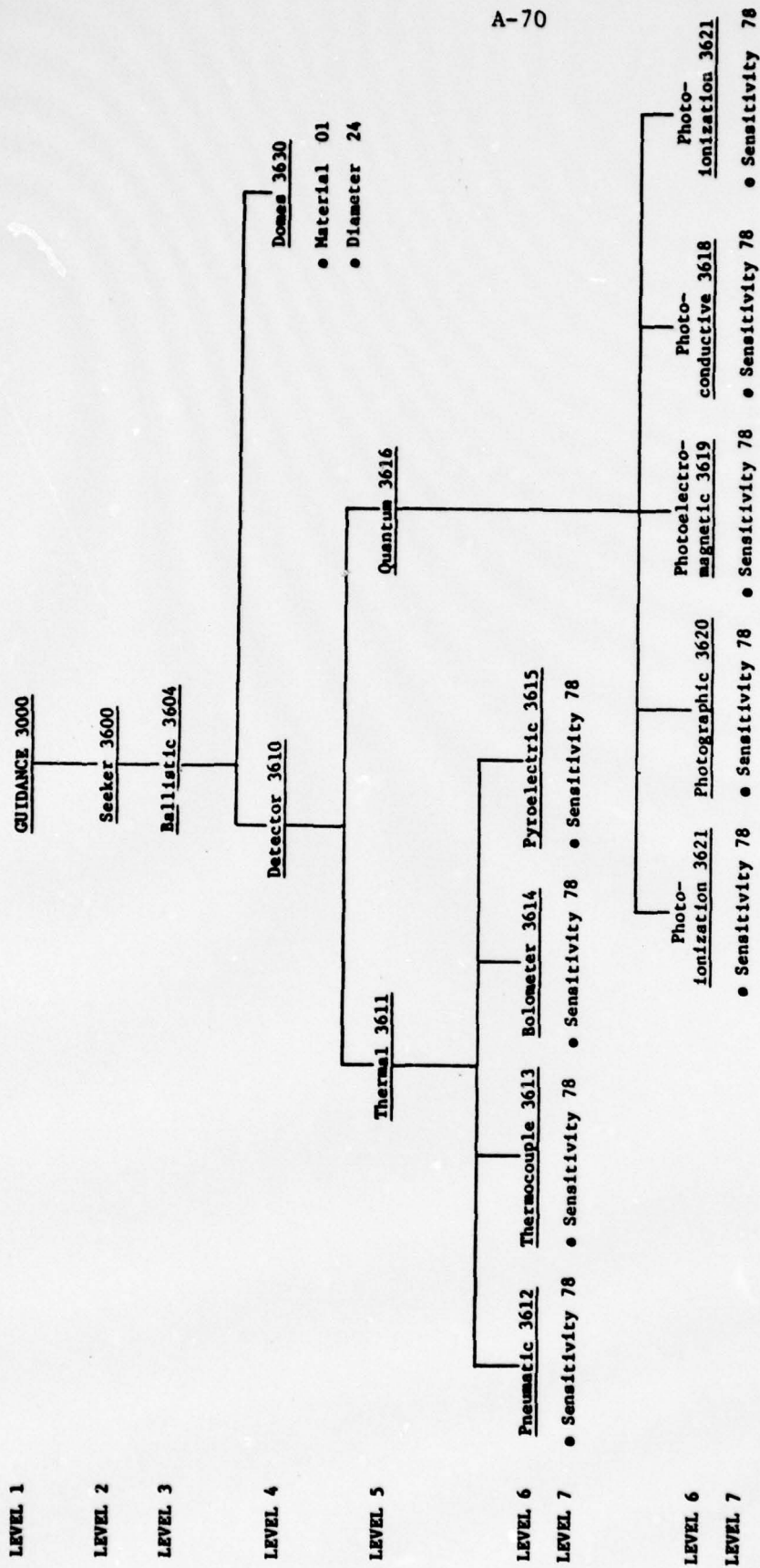


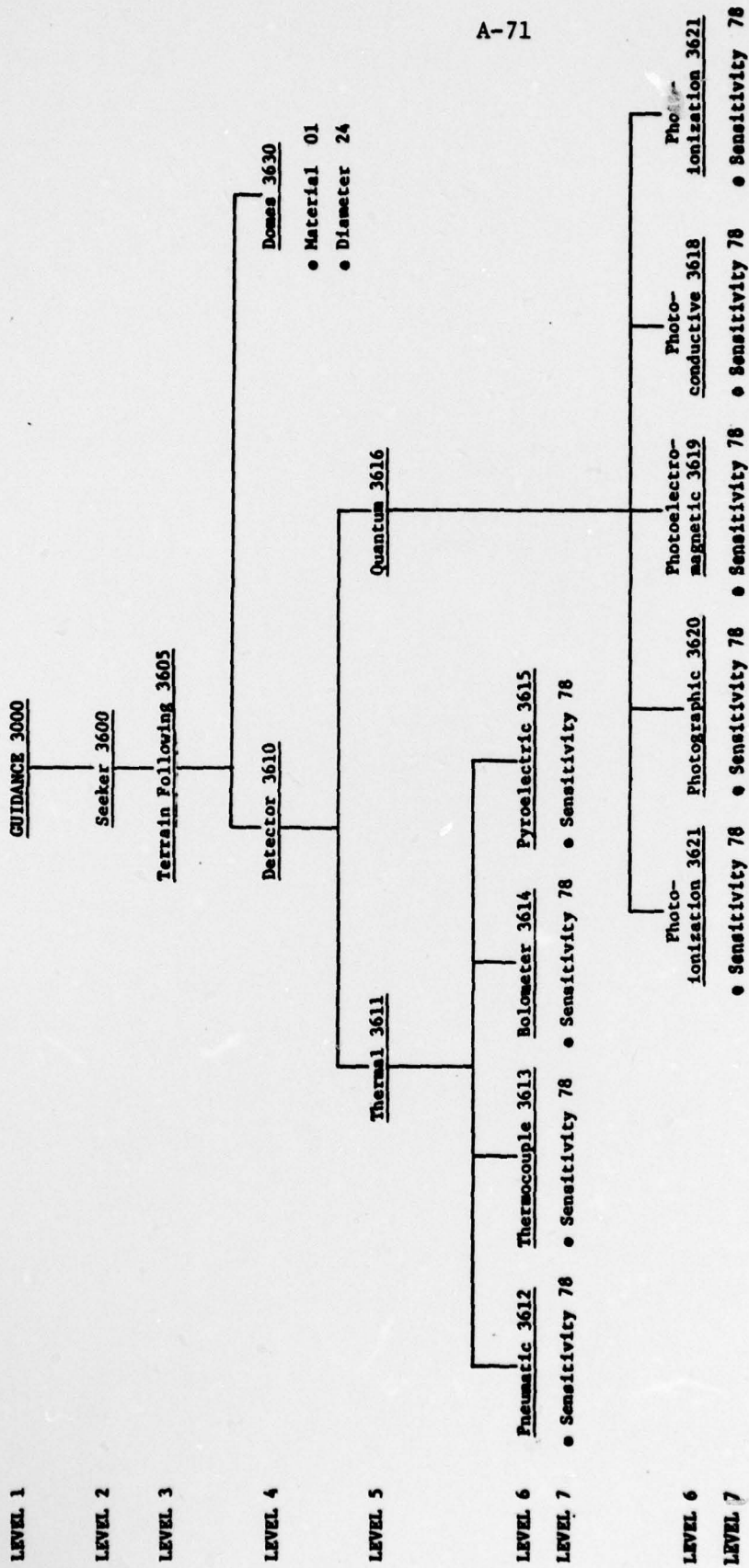


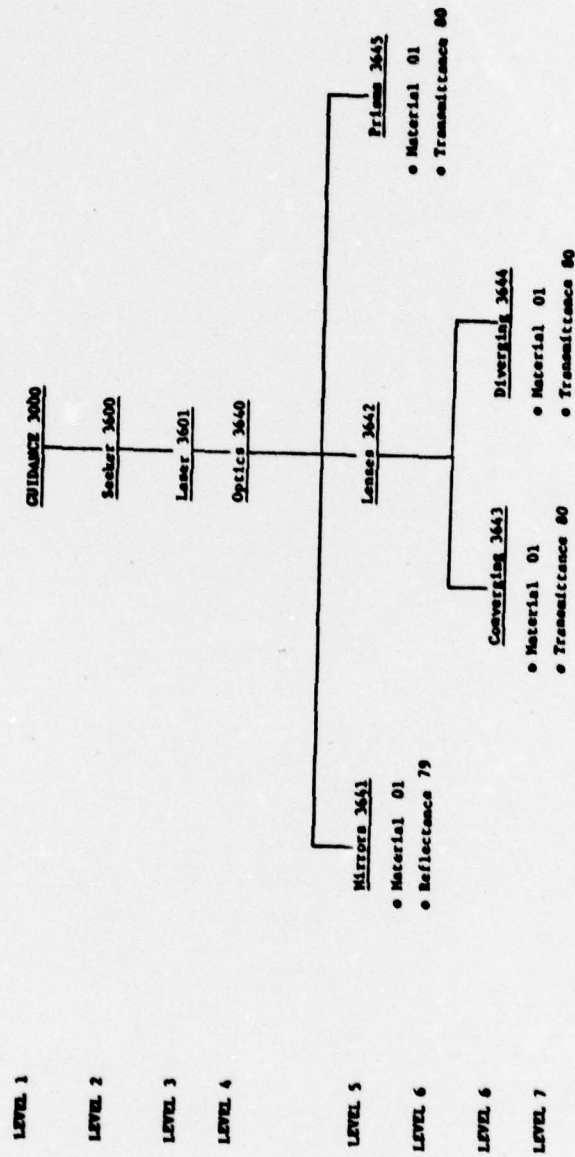












LEVEL 1

LEVEL 2

LEVEL 3

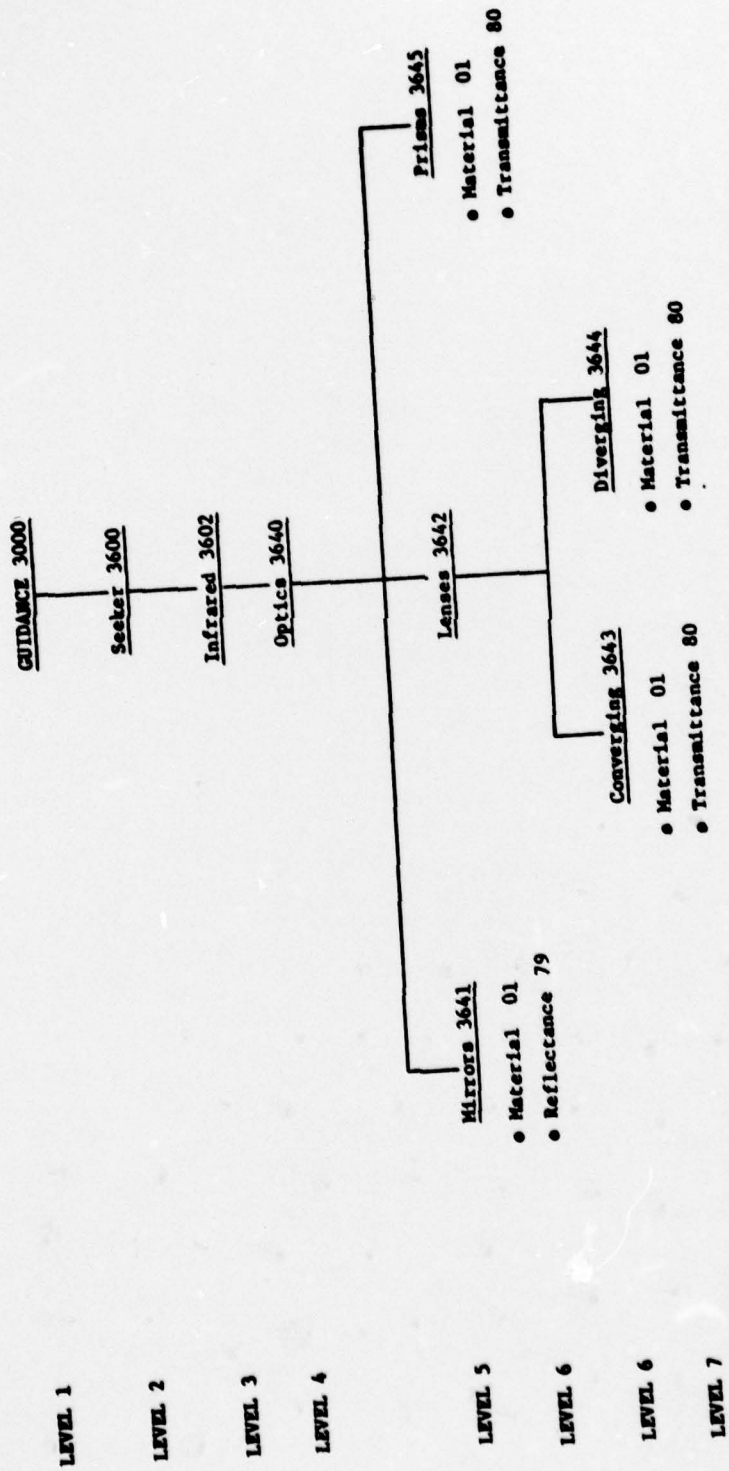
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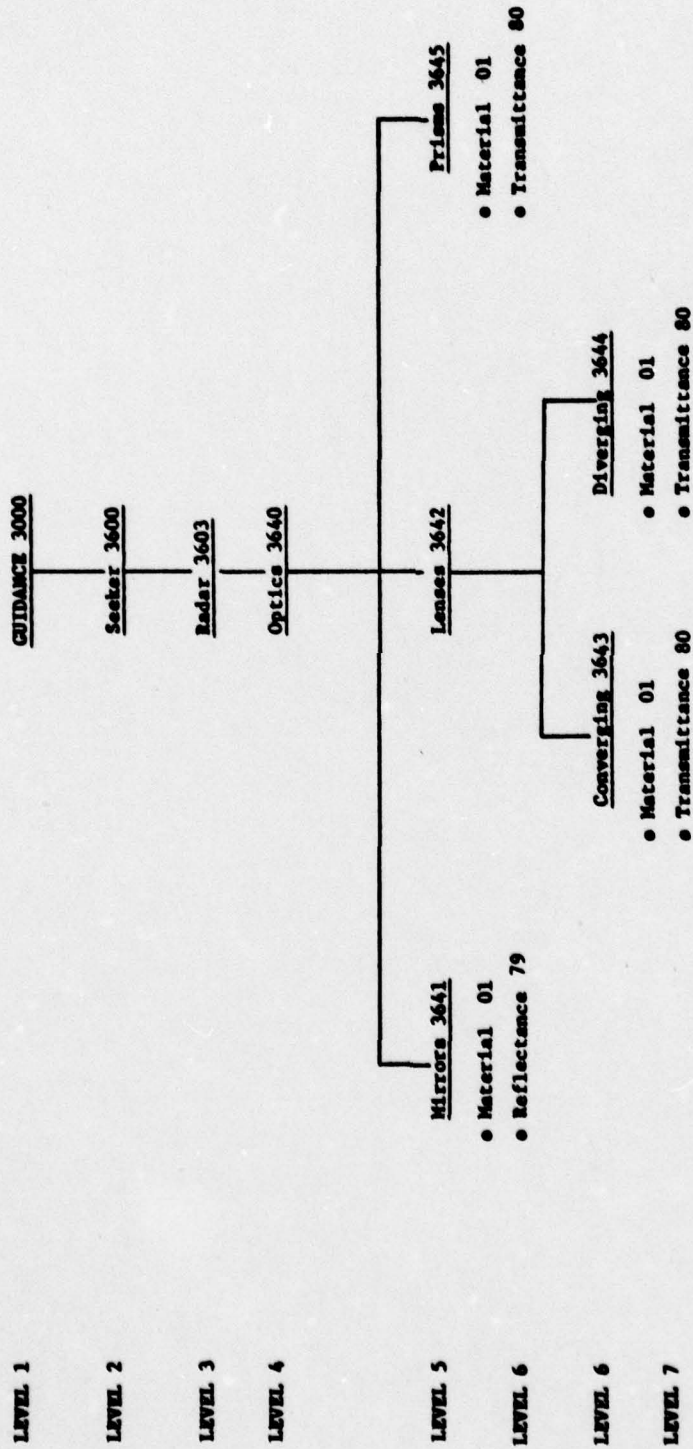
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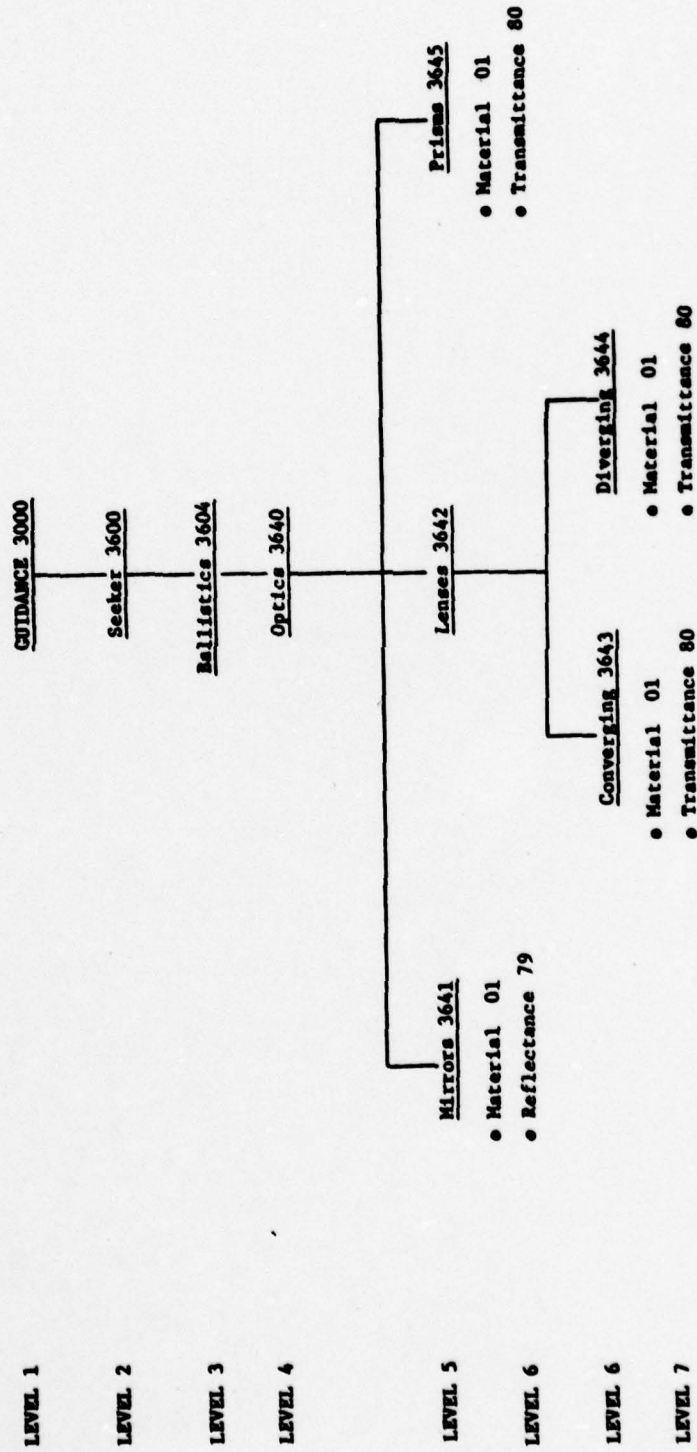
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LEVEL 6

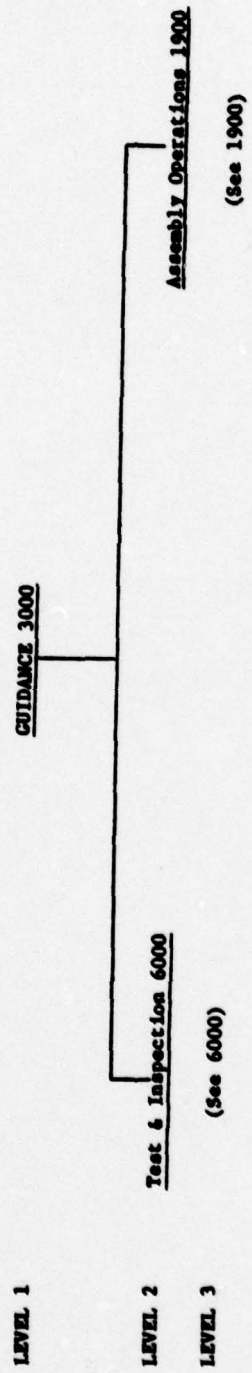
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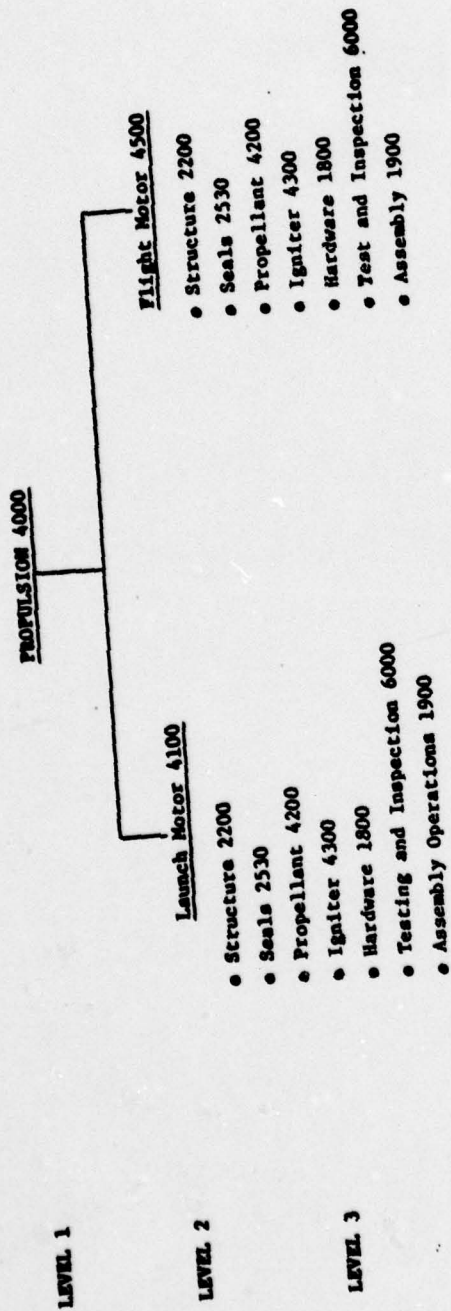


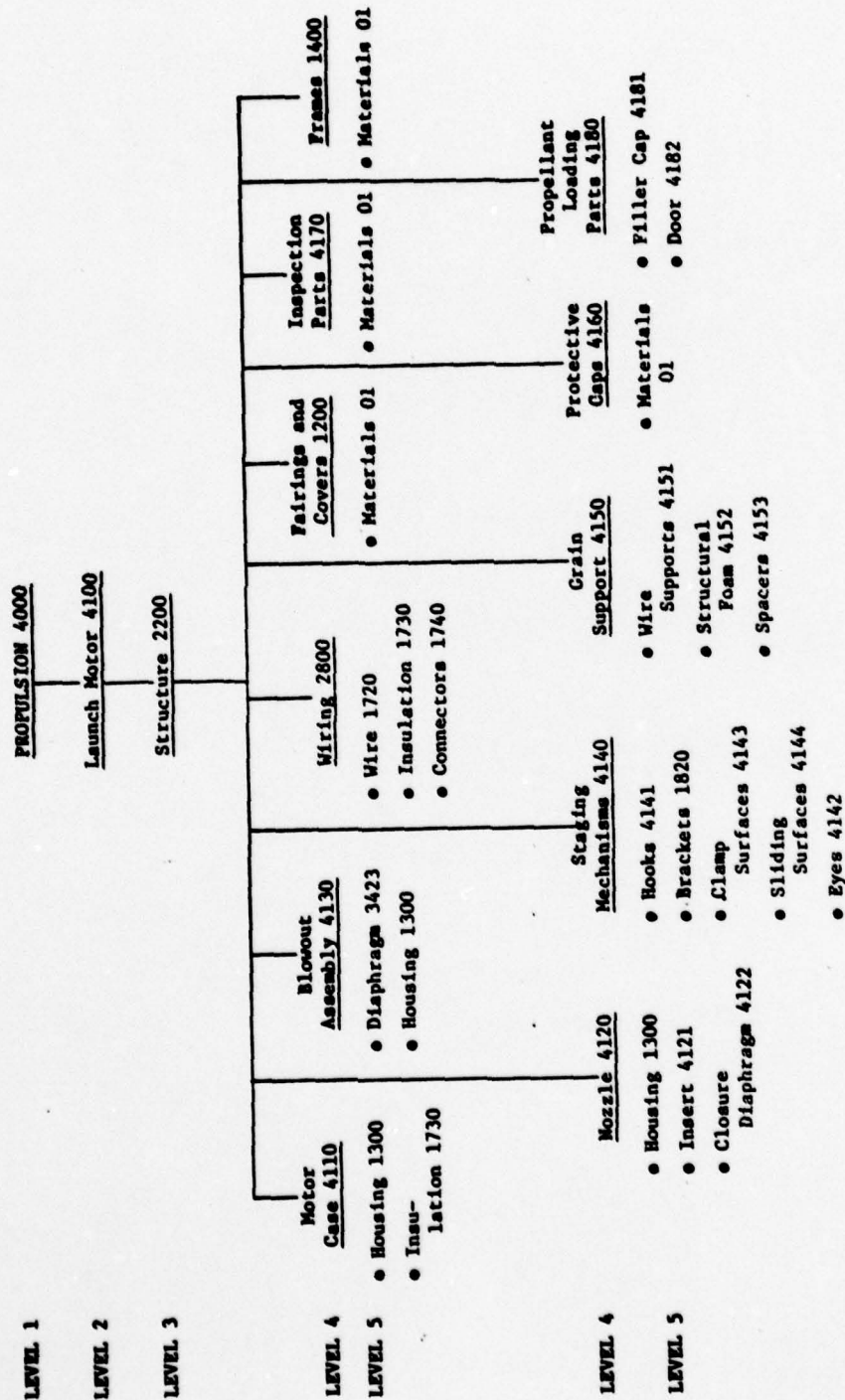


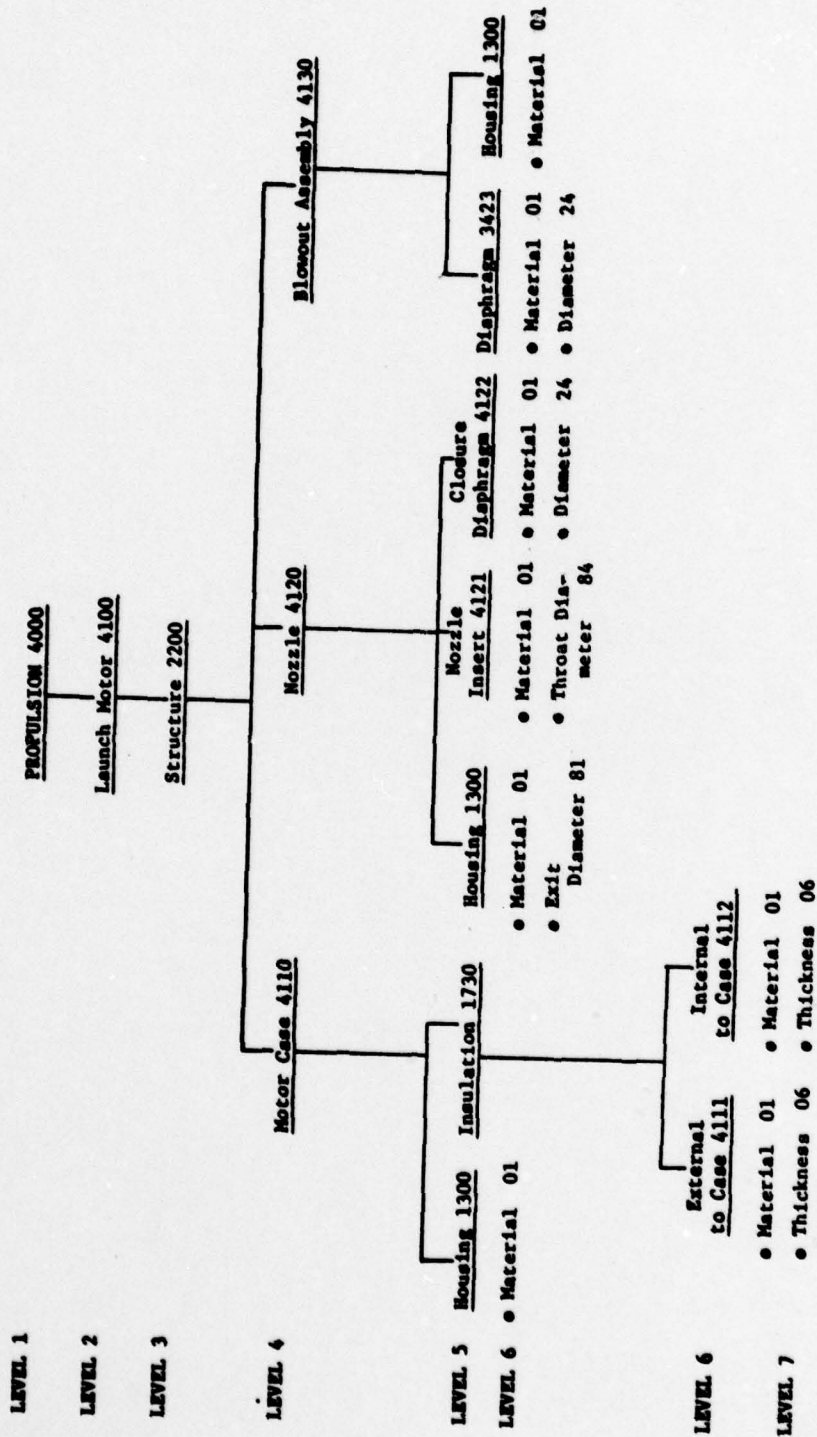


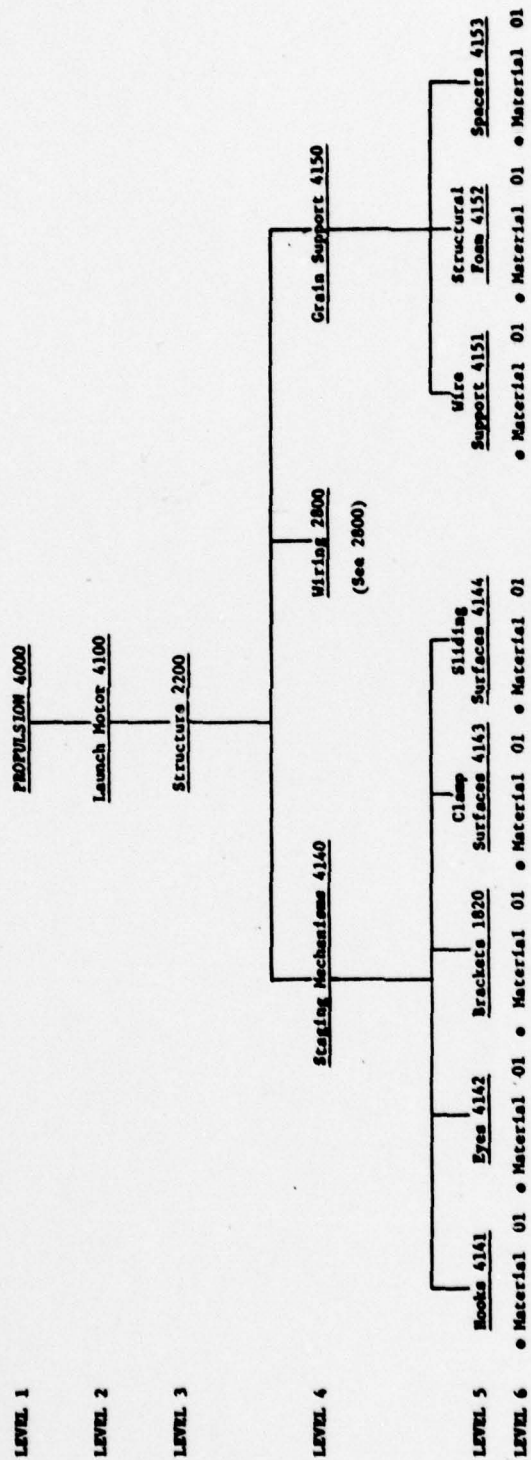


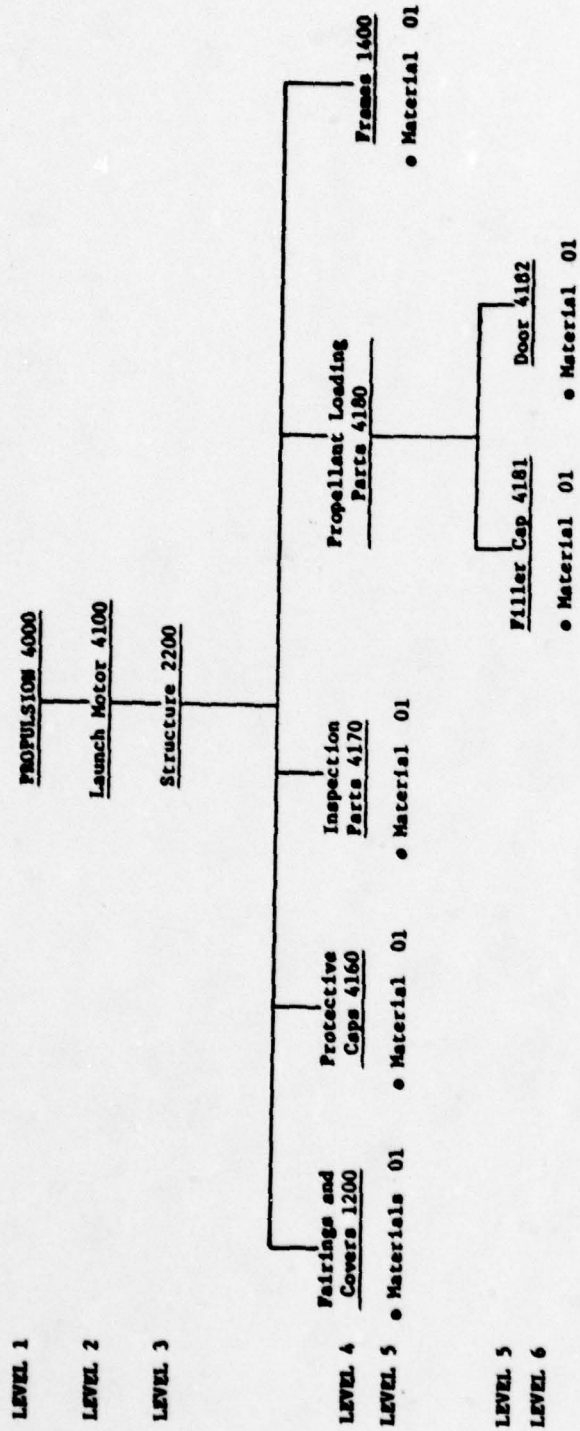


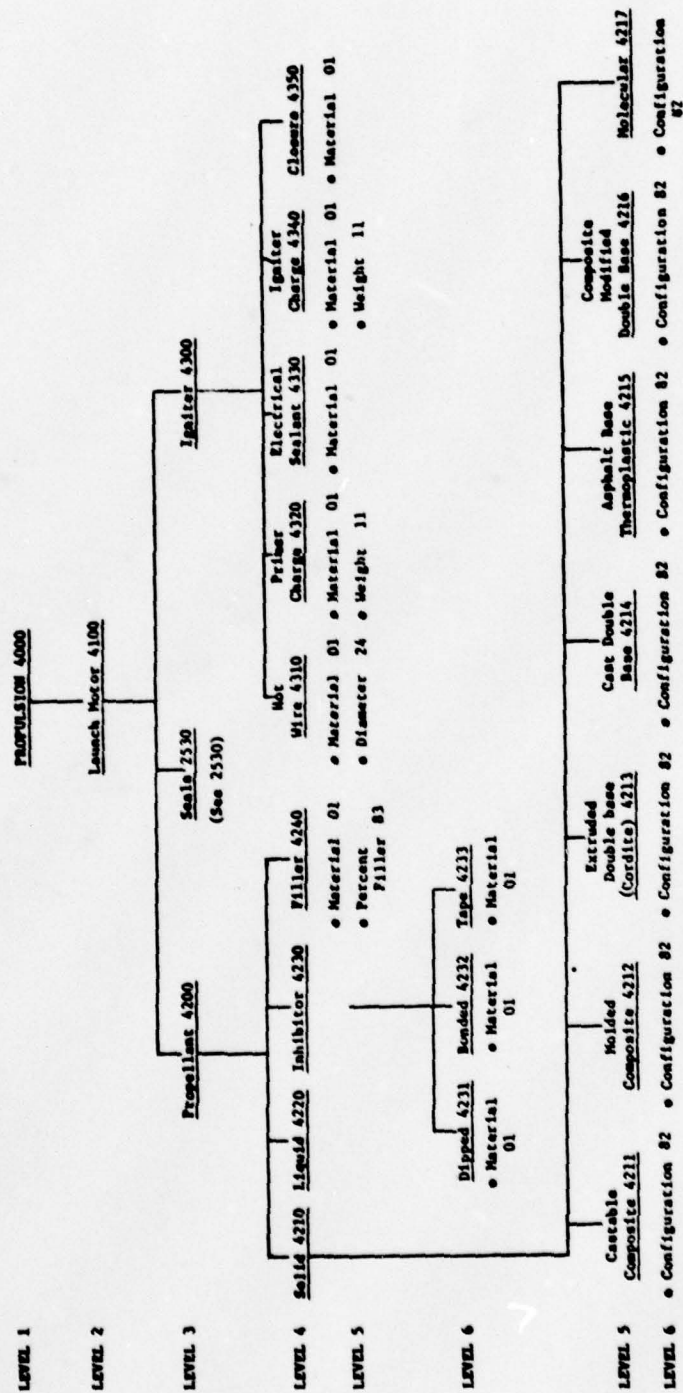


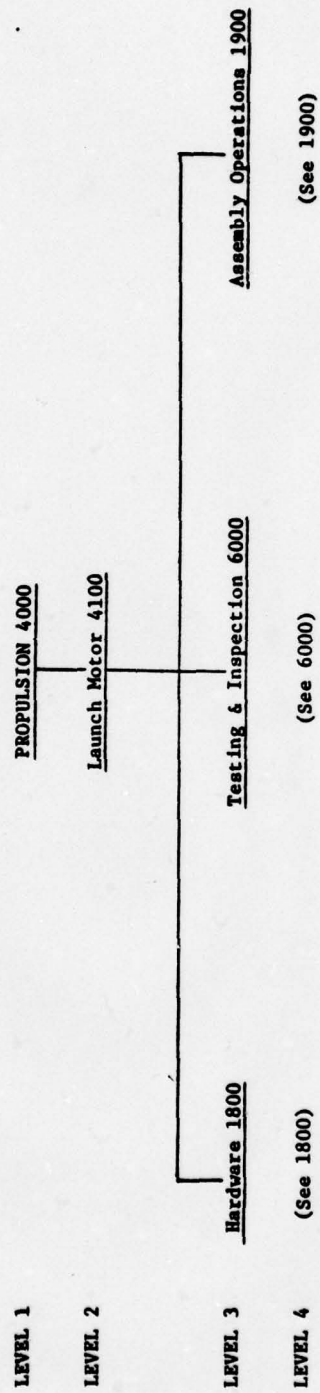












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PROPULSION 4000

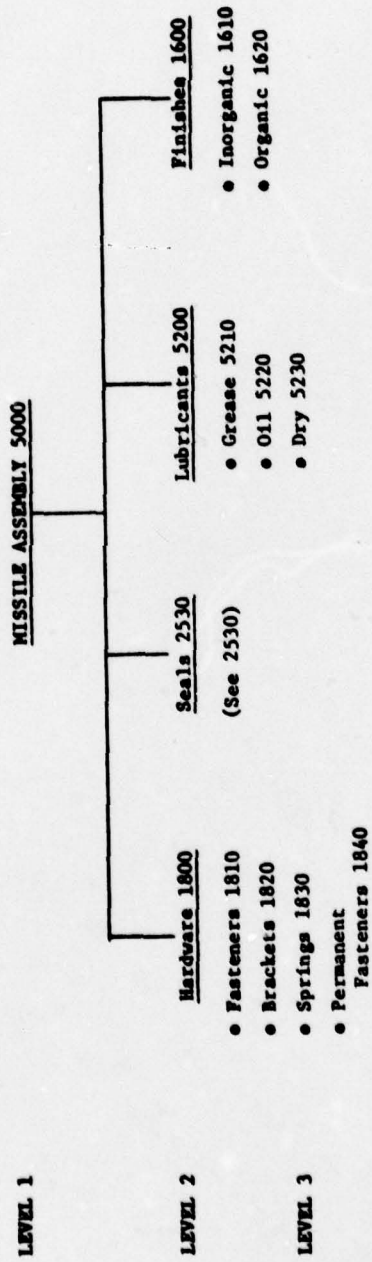
Flight Motor 4500

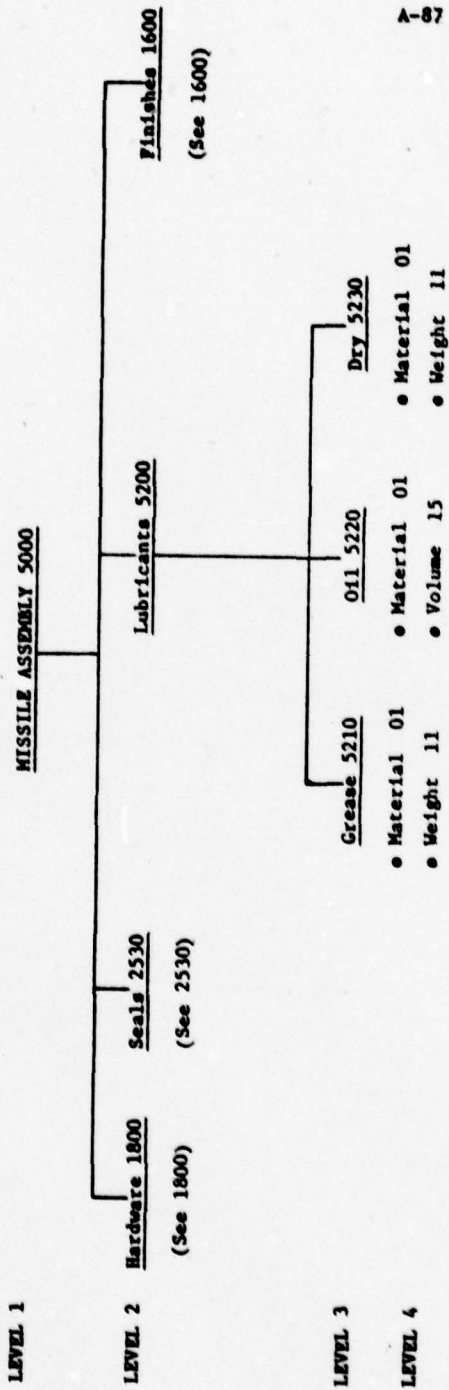
(See 4100)

LEVEL 1

LEVEL 2

LEVEL 3





TESTING AND INSPECTION 6000

LEVEL 1

Structural Tests 6100

LEVEL 2

Electrical Tests 6200

LEVEL 3

X-Ray 6110
• Labor Date 12

• Labor Rate 12

Scanning 6130

• Labor	
Rate	12

Acoustic 6140
e Labor
Rate 12

Visual 6150
• Labor
Rate 12

Continuity 6210

• Labor Rate 12

Leakage 6220
• Labor Rate 12

Visual 6150
• Labor Rate 12

A-89

CHARACTERISTIC CODING

CHARACTERISTIC AREA CODING

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L x Diameter	04
Torque	05
Thickness	06
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Size	08
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Labor Rate	12
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CHARACTERISTIC AREA CODING (Continued)

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Burn Time	76
Rate	77
Sensitivity	78
Reflectance	79
Transmittance	80
Exit Diameter	81
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Percent Filler	83
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Material 01 (001-125)

Steel	001
Aluminum	002
Stainless Steel	003
Composites	004
Plastics	005
Tin	006
Lead	007
Chromium	008
Copper	009
Copper Alloy	010
Nickel	011
Zinc	012
Cadmium	013
Gold	014
Silver	015
Platinum	016
Vinyl	017
Rubber	018
Nylon	019
Varnish	020
Neoprene	021
Polyethylene	022
Polypropylene	023
PVC	024
Teflon	025
Cadmium Plating	026
Silicone	027
Furane	028
Epoxy	029
Polyurethane	030
Polyester	031
Phenolic	032
Inorganic Zinc	033
Acrylic	034
Asphaltic	035
Sodium Nitrate	036
Manesium	037
Polyamide	038
Butadiene Styrene	039
Chlorinated Rubber	040
Chlorosulfonated } Polyethylene }	041
Chromate Plating	042
Rhodium	043
Alumina Oxide	044
Ceramic	045

Material 01 (001-125) (Continued)

Ethylene propylene terpolymer (EPT)	046
Fluoroelastomer	047
Glass-reinforced thermoplastic	048
Brass	049
Beryllium Copper	050
Polyallomer	051
Ethylene vinyl acetate	052
Petroleum base	053
Nitrogen	054
Helium	055
Silica Gel	056
Buna - N	057
Felt	058
Rubber + Fabric	059
Rubber + Cord	060
Rubber + Cord + Fabric	061
Rubber + Nylon	062
Rubber + Polyamide	063
Cast Iron	064
Molecular Sieves	065
Laminac	066
Glass/Silver	067
Quartz	068
Di-electrics	069
Spinel	070
Silicon Nitride	071
Pyrex	072
Fused Silica	073
Petroleum	074
Synthetic (oil or grease)	075
Molybdenum Disulfide	076
Graphite	077
Titanium	078
Glass Fiber	079
Ablative	080
Buna - S	081
Butyl Rubber	082
Polysulfide	083
Polyisoprene	084
Polyacrylic	085
Tungsten	086
Carbide	087
Molybdenum alloy	088
Inorganic salts	089
Oils	090
Resins	091
Waxes	092
Silica	093
Asbestos	094

A-94

Material 01 (001-125) (Continued)

Carbon	095
Inorganic Hydrate	096
Potassium titanate	097
Phenolic cork	098
Potassium nitrate	099
Black powder	100
Fluorocarbon	101
Silicon Oil	102

Area 02 (126-140)

<10 in ²	126
10-100 in ²	127
>100 in ²	128
<1 ft ²	129
1-10 ft ²	130
>10 ft ²	131

Fabrication Method 03 (141-165)

Cast	141
Forged	142
Machined Sheet	143
Molded	144
Formed Plate	145
Rolled & Welded	146
Seamless Tube	147
Combination	148
Electrodeposition	149
Flame sprayed	150
Clad	151
Hot dipped	152
Vapor deposition	153
Diffusion	154
Anodized	155
Phosphatized	156
Chromatized	157
Oxide	158
Glass coated	159
Rolled	160

Length x Diameter 04 (166-200)

<2" x 1/4"	166
2 - 4" x 1/4" - 1/2"	167
>4" x 1/2"	168
3 x <1/4"	169
3 - 5 x 1/4" - 1/2"	170
5" x >1/2"	171
3" x <3/8"	172
3 - 5" x 3/8" - 1/2"	173
5 - 6" x 1/2" - 7/8"	174
6" x >7/8"	175
1 ft x <0.010 in	176
1 - 5 ft x 0.010 - 0.050 in	177
5 ft x >0.050 in	178
<1 ft x <0.25 in	179
1 - 5 ft x 1/4" - 1/2"	180
>5 ft x >1/2"	181
<3000 ft x <0.001 in	182
3000 ft - 5000 ft x 0.001 - 0.005"	183
>5000 ft x >0.005 in	184
1/2" x <1/8"	185
1/2 - 1" x 1/8" - 1/4"	186
1 - 2" x 1/4 - 1/2"	187
2" x >1/2"	188

Torque 05 (201-220)

<0.1 in. oz	201
>0.1 in. oz	202
<0.1 in. oz	203
>0.1 in. oz	204
<4 in. - oz	205
>4 in. - oz	206
>10 in. - oz	207
<10 in. - oz	208
<40 in. - oz	209
>40 in. - oz	210
<0.25 in. - lb	211
>0.25 - 2.5 in. - lb	212
>2.5 in. - lb	213
<1 in. - lb	214
>1 in. - lb	215

A-97

Thickness 006 (226-235)

<0.001"	226
0.001 - 0.15"	227
>0.015"	228
<0.25 in.	229
0.25 - 1 in.	230
1 in.	231

Length 007 (236-250)

<1 ft	236
1 - 5 ft	237
>5 ft	238
<3000 ft	239
3000 - 5000 ft	240
>5000 ft	241
<6"	242
>6"	243

Size 08 (251-265)

Standard	251
Miniature	252
20	253
16	254
12	255
8	256
4	257
0	258

A-98

Number Pins 09 (266-275)

1 - 4	266
5 - 20	267
>20	268

Spring Rate 10 (276-290)

<1/4 lb/in.	276
1/4 - 2 1/2 lb/in.	277
>2 1/2 lb/in.	278
<1 lb/in.	279
1 - 10 lb/in.	280
>10 lb/in.	281

Weight 11 (291-310)

<0.1 oz	291
0.1 - 1 oz	292
>1 oz	293
<0.1 lb	294
0.1 - 0.25 lb	295
>0.25 lb	296
<1 lb	297
1 - 10 lb	298
>10 lb	299
<5 lbs	300
>5 lbs	301

A-99

Labor Rate 12 (511-515)

Automatic	511
Manual	512

Pressure 13 (311-325)

<100 psi	311
100 - 2500 psi	312
>2500 psi	313
<500 psi	314
500 - 2599 psi	315
<1000 psi	316
>1000 psi	317

Temperature 14 (326-335)

<0°F	326
0 - 150°F	327
>150°F	328

Volume 15 (335-350)

<4 in. ³	336
4 - 20 in. ³	337
>20 in. ³	338
<1 SCF	339
1 - 10 SCF	340
>10 SCF	341
<0.1 liter	342
0.1 - 0.5 liter	343
>0.5 liter	344

Volume Produced 16 (351-355)

<1000 cc	351
>1000 cc	352

A-101

Power Source 17 (356-365)

Pneumatic actuator	356
Electrical actuator	357
Mechanical actuator	358
Pyrotechnic actuator	359

Number Connections 18 (366-375)

2 - 5	366
5 - 10	367
>10	368

Shaft Diameter 019 (221-225)

<1/2"	471
>1/2"	472
<1/8"	221
1/8 - 1/4"	222
1/4 - 1/2"	481

Duty 20 (376-380)

Intermittent	376
Continuous	377

A-102

Voltage 21 (381-450)

0 - 25	381
<1	382
1 - 3	383
3	384
3 - 6	385
6	386
6 - 12	387
10	388
12	389
>12	390
15	391
16	392
20	393
24	394
>24	395
25	396
25 - 100	397
35	398
50	399
>50	400
<75	401
75	402
>75	403
<100	404
100	405
>100	406
100 - 300	407
120	408
150	409
200	410
250	411
300	412
300 - 100	413
350	414
400	415
>400	416
600	417
800	418
>1000	419
1200	420
1600	421

A-103

Lift 22 (451-460)

<10 oz	451
10 - 50	452
50 - 100 oz	453
>100 oz	454

ID x Length 23 (461-470)

<1/2" x <3"	461
1/2" - 2" x 3" - 6	462
>2" x >6"	463

Diameter 24 (481-500)

<1/2"	471
>1/2"	472
1/4 - 1/2"	481
<0.001"	482
0.001 - 0.01"	483
>0.01"	484
<1/4"	485
<1"	486
>1"	487
1 - 3"	488
>3"	489
1/2 - 1"	490

Stroke 25 (471-480)

<1/2"	471
>1/2"	472
<1"	473
>1"	474

A-104

Capacity 26 (516-520)

<1/2"	471
>1/2"	472

Linkage Connections 27 (531-540)

Pinned	531
Sliding	532
Screw	533
Ball	534

Number Teeth 28 (521-530)

<30	521
30 - 50	522
>75	523

A-105

W x L 29 (541-550)

<1/2" x 6"	541
1/2" - 1" x 6 - 20"	542
>1" x 20"	543

W x D 30 (551-560)

<1/2" x 6"	551
1/2 - 1" x 6 - 10"	552
>1" x 10"	553

A-106

Collector Current 31 (561-575)

<50 mA	561
50 - 500 mA	562
>500 mA	
<1 A	563
1 - 5 A	564
>5 A	565
<3 A	566
3 - 10 A	567
>10 A	568

Collector emitter voltage 32 (576-590)

<30 v	576
30 - 80 v	577
<40 v	578
40 - 80 v	579
>80 v	580

Current-gain product bandwidth 33 (591-600)

<100 MHz	591
>100 MHz	592

Drain current 34 (601-610)

<20 ma	601
20 - 150 ma	602
>150 ma	603

Drain-source voltage 35 (611-615)

<30 v	576
>30 v	612

A-107

Reliability Level 36 (616-620)

High	616
Standard	617

Complexity 37 (621-635)

SSI	621
MSI	622
LSI	623
VLSI	624
High	625
Low	626
ROM only	627
ROM/RAM	628
ROM/RAM/TIMER	629
Other	630

Speed 39 (636-640)

High	616
Standard	617

Quality 40 (641-645)

High	616
Standard	617

Offset 41 (646-650)

High	616
Standard	617

Current Capacity 42 (651-665)

>5a	565
>10a	568
1a	651
3a	652
<5a	653
5a	654
5 - 10	655
<10a	656
10 - 25	657
>25	658

Bit Capacity 43 (666-680)

8 - 64	666
64 - 256	667
256 - 1	668
<1K	669
1K	670
4K	671
8K	672
16K	673
>16K	674

Access Time 44 (681-695)

<60 ns	681
>60 ns	682
<200 ns	683
200 - 500 ns	684
<400 ns	685
>400 ns	686
500 ns - 1 μ s	687
>1 μ s	690

Operating Speed 45 (696-700)

<5 MHz	696
>5 MHz	697

Bit Size 46 (701-710)

4	701
8	702
16	703
18	704

Clock Rate 47 (711-715)

<1 MHz	711
1 - 10 Mz	712
>10 Mz	713

Word Length 49 (716-720)

4 bit	716
8 bit	717
16 bit	718
32 bit	719

Word Capacity 48 (721-725)

1K	670
4K	671
8K	672
16K	673
32K	721
64K	722

A-110

Rolloff 51 (726-730)

40 dB/decade	726
80 dB/decade	727
120 dB/decade	728

Tolerance 52 (731-750)

<0.001%	731
>0.001%	732
±0 - 2%	733
2 - 5%	734
±2 - 20%	735
<5%	736
5%	737
5 - 10%	738
±0 - 10%	739
±>10%	740
>10%	741
10%	742
<1.5%	743
>1.5%	744
>5%	745
±>20%	746

Drift Rate 53 (751-755)

>1 ppm/°C	751
<1 ppm/°C	752

Capacitance 54 (756-800)

<0.01 μ F	756
0.01 - 0.02 μ F	757
0.02 - 0.05 μ F	758
0.05 - 0.1 μ F	759
0.1 - 0.22 μ F	760
>0.22 μ F	761
\leq 0.02 μ F	762
>0.02 μ F	763
<0.1 μ F	764
\geq 0.1 μ F	765
<10 pF	766
10 - 250 pF	767
250 - 1500 pF	768
0.0015 - 0.01 μ F	769
>0.01 μ F	770
<0.25 μ F	771
0.25 - 0.5 μ F	772
0.5 - 2.0 μ F	773
>2.0 μ F	774
<0.04 μ F	775
0.04 - 0.25 μ F	776
0.25 - 1.0 μ F	777
>1.0 μ F	778
0.01 - 0.05 μ F	779
0.05 - 0.22 μ F	780
0.22 - 1.0 μ F	781
<15 μ F	782
15 - 50 μ F	783
100 - 200 μ F	784
200 - 500 μ F	785
500 - 1500 μ F	786
1500 - 5000 μ F	787
5000 - 10,000 μ F	788
>1000 μ F	789
<50 pF	790
50 - 100 pF	791
100 - 250 pF	792
>250 pF	793
10 - 100 pF	794
100 - 1000 pF	795
>1000 pF	796

A-112

Failure Rate 55 (801-805)

>2%	801
2%	802
1%	803

Q Level 56 (806-810)

High	616
Low	646

Wattage 57 (811-830)

1/8 w	811
1/4 w	812
1/2 w	813
1 w	814
2 w	815
5 w	816
10 w	817
>10 w	818
20 w	819
<25 w	820
25 w	821
>25 w	822
50 w	823
>50 w	824

Resistance 58 (831-845)

10 ohms	831
10 - 1000" ohms	832
1000 - 5000" ohms	833
<10,000 ohms	834
>10,000 ohms	835
<20K ohms	836
>20K ohms	837
5000 - 50,000 ohms	838
10K - 50K ohms	839
>50K ohms	840
1 - 1 meg	841
>1 meg	842

Maximum energy 59 (846-850)

<1 joule	846
1 - 10 joule	847
>10 joule	848

Time Constant 60 (851-855)

<2 sec	851
>2 sec	852

Linearity 61 (856-860)

<1%	856
>1%	857

Precision 62 (861-865)

0.1%	861
0.1 - 0.25%	862
0.25%	863

Turns 63 (866-870)

Single	866
Multiple	867

Inductance 64 (871-875)

Fixed	871
Adjustable	872

Response 65 (876-880)

Narrow band	876
Wide band	877

A-115

Coil Voltage 66 (881-885)

6v	386
12v	389
24v	394
> 24v	395

Contact Rating 67 (886-890)

<10a	568
5 - 10a	655
>1a	886

Contact arrangement 68 (891-895)

A	891
B	892
C	893

Input Voltage 69 (895-900)

<30v	576
>30v	612

Number Contacts 70 (901-905)

1	901
2	902
3	903
4	904

Shelflife 71 (906-910)

<1 yr	906
1 - 3 yr	907
3 - 5 yr	908
>5 yr	909

Accuracy 72 (911-925)

<3 min	911
>3 min	912
<±2 min	913
>±2 min	914
<0.5 min	915
>0.5 min	916
<±1°F	917
>±1°F	918
<±2%	919
>±2%	920
<±5 psi	921
>±5 psi	922

Thermal Conductivity 73 (926-930)

<.02 BTU/hr-ft-°F	926
.02-.05 BTU/hr-ft-°F	927
>.05 BTU/hr-ft-°F	928

A-117

Diameter x Stroke 74 (931-935)

<0.5 in. x 1"	931
0.5 - 1.0" x 1 - 3"	932
>1.0" x 3"	933

Brightness 75 (936-940)

<0.1 foot lambert	936
0.1 - 1.0 foot lambert	937
>1.0 foot lambert	938

Burn Time 76 (941-945)

<30 sec	941
30 - 60 sec	942
>60 sec	943

Rate 77 (946-950)

<60Hz	946
>60Hz	947

Sensitivity 78

Displayed graphically
for each instrument

Reflectance 79 (951-955)

<98%	951
>98%	952

Transmittance 80 (956-957)

<98%	956
>98%	957

Exit Diameter 81 (958-960)

<1/2"	471
>1"	487
1/2 - 1"	958

Configuration 82 (966-999)

Spool valve	966
Poppet	967
Diaphragm	968
Shear valve	969
Rotary valve	970
Restricted (Inhibitor)	971
Unrestricted, Single Hollow charge	972
Unrestricted, Multiple Hollow charge	973
Rod & Tube	974
Internal Burning, Star	975
Internal Burning, Multiperforated	976
Internal Burning, clover leaf	977
External burning - cruciform	978
Multi-propellant	979

A-119

Percent Filler 83 (964-965)

<20%	964
>20%	965

Throat Diameter 84 (961-963)

>1/2"	472
1/4 - 1/2"	481
<1/4"	485

APPENDIX B

DEFINITIONS

APPENDIX B

DEFINITIONS

Acoustooptic Modulation	-- Varies light transmitted by varying ultrasonic waves through material.
Actuators	-- Any mechanism for converting energy into mechanical motion.
Assembly	-- Any joining action where a set of parts are premanently or temporarily attached in building the missile.
Blow Out Assembly	-- Relief built into the rocket motor.
Case	-- The outer container of the rocket motor.
Control	-- Parts which physically adjust the missile direction including moving fins, actuators, power sources, linkage, etc.
Control Surfaces	-- Moveable wings and flaps which change the course of the missile.
Control Wire	-- The trailing wire, connections and insulation which are the data link in a wire guided missile.
Cryostat	-- System which provides a very cold environment.
Detector	-- The unit in the seeker which receives and deciphers the target energy from all external noise energies.
Electronics	-- All electrical components, circuit cards, instruments, and systems not including wiring and connectors between units.
Electrooptic Modulation	-- Varying light transmitted by a material due to varying electric field in it.
EMI	-- Electromagnetic interference here used as equipment to reduce the noise in electrical circuits
Environmental Controls	-- Equipment to monitor and control any environmental variable (temperature, humidity, pressure etc.) around any portion of the missile.

Fabrication	-- Any operation using raw material to form a part--as opposed to <u>assembly</u> which forms a part from other parts.
Fairings	-- Any covering or enclosure primarily for reduction of wind resistance and not structural integrity.
Filter (Optical)	-- An optical part used to eliminate all frequencies except those desired from the generated light.
Finishes	-- Any coating or covering layer of material added to any part to prevent corrosion, to disguise the missile, to identify the missile, to prevent EMI, etc.
Flight Motor	-- The motor used for sustained flight.
Floatation Fluid	-- Fluid surrounding the gimbals in some gyros to reduce the torques generated by bearings.
Frames	-- Any part which connects or supports major portions of the missile which are enclosed in housings.
Guidance	-- Parts determining the missile direction of travel, comparison of the actual direction to the desired direction, and producing the required error signal. Electrical power supplies are arbitrarily located in this section.
Gyro-Optics	-- Gyro type bearings and gimbals which keep the detector optics pointed toward the target.
Gyroscope	-- Any instrument which determines a change in attitude and is stabilized by one or more spinning rotors.
Hardware	-- The extraneous fasteners, brackets, springs, clips, etc. used in general assembly.
Housings & Covers	-- Any container, covering or enclosure used as a structural support for any part or group of parts.

Igniter	-- Starter for the rocket motor.
Inspection Ports	-- Doors or windows used to internally inspect the rocket motor.
IR Source	-- Usually a pyrotechnic flare, filtered and modulated to flash infrared light at the frequency required to allow an accurate fix between the launcher and missile.
Launch Motor	-- The motor or gas generator used only to eject the missile from the tube or launch rack.
Launch Provisions	-- Those parts on a missile whose function is to provide stability and protection for the missile while it is in the launch tube or rack. Also included are all hooks, releases, and tie-downs that must be disconnected to allow launch.
Lift Surfaces	-- Any wing, airfoil, or lifting body surface which provides lift to the missile. Does not include moveable wings or flaps.
Magnetooptic Modulator	-- Varies light transmitted by varying magnetic field in material.
Material	-- The basic elements or compounds from which the parts are fabricated.
Missile	-- The part of a missile system which becomes airborne at launch, i.e., the flight vehicle.
Modulator	-- Controller to pulse the light beam at the required frequency and pattern.
Monitoring Instruments	-- Measurement device which determines the error between the desired reading and the actual reading of an environmental variable.
Nozzles	-- The exit point for the high pressure gas generated in the rocket motor.

- | | |
|---------------------------------|---|
| Output Pickoffs | -- Any device to indicate when the gyro moves from its standard position. It is connected to a torquing device to correct the gyro position. |
| Pendulous Reference Devices | -- Units which indicate the vertical direction by using a pendulum. The gyro can then be referenced to the average pendulum position. |
| Plumbing | -- All parts which provide storage, transport, and control of a working fluid. This includes piping, fluid, fittings, manifolds, storage tanks and valves. |
| Propellant | -- The chemical which burns to form the high pressure gases. |
| Propellant Loading Parts | -- Mechanical parts to allow entrance to the case to load the propellant. |
| Propulsion | -- All parts of the rocket motor or motors or gas generators used for propulsive force. |
| Protective Caps | -- Covers for nozzles and other openings in rocket motor. |
| Quantum | -- Photon type detectors which count the number of incident photons. |
| Seeker | -- Unit which determines the direction to the target. |
| Structures | -- All parts whose function is to support, enclose, protect, and cover the rest of the parts in the missile. For example, frames, housings, fairings. Also included are parts whose function is too general to be included in another section such as wire harness, finishes. |
| Temperature Control (Gyroscope) | -- Precise control of the temperature of the fluid in a gyroscope is necessary to maintain a constant viscosity and thereby a constant relationship between torque generated and velocity. |
| Test and Inspection | -- Any check, inspection, test or other action to determine the quality of the part, material, or assembled parts. |

Thermal

- Detectors which sense the change in temperature due to the absorption of incident radiation.

Torquing Devices

- Any unit which applies torque to the axis of a gyroscope to compensate for drift.

Wire Harness

- System of wire and connectors complete and installed as a unit as opposed to single wires which are cataloged in the sections they are connected to.

Wiring

- The wire, insulation, and connections that connect different electronic units to themselves and other parts. The wiring is cataloged under the section it is used in.

APPENDIX C

REFERENCES

APPENDIX C

REFERENCES

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